

## 3.2 Water Quality

This section describes the effects of the Proposed Action and alternatives on water temperature, suspended sediments, nutrients (total phosphorus [TP], total nitrogen [TN], ortho-phosphorus, nitrate, and ammonium), dissolved oxygen, pH, algal toxins and chlorophyll-*a*, and inorganic and organic contaminants within the area of analysis. Effects of the Proposed Action and alternatives on the algal community (phytoplankton, aquatic macrophytes, riverine phytoplankton and periphyton) in the area of analysis are discussed in Section 3.4, Algae. Algal toxins are a water quality concern that affect designated beneficial uses of water, so this section also includes a brief analysis of project effects on algal toxins as related to beneficial uses. Similarly, water quality parameters relevant to the analysis of fish disease and parasitism (e.g., water temperature, nutrient availability) are included here as part of the Proposed Action effects analysis; the full analysis of fish disease and parasitism is in Section 3.3, Aquatic Resources.

### 3.2.1 Area of Analysis

The area of analysis for water quality includes the Upper and Lower Klamath Basins (see Figure 3.2-1), which for the purposes of the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) are organized into the following analysis segments:

#### Upper Klamath Basin

- Wood, Williamson, and Sprague Rivers
- Upper Klamath Lake
- Link River Dam to Klamath River upstream of J.C. Boyle Reservoir
- Hydroelectric Reach (J.C. Boyle Reservoir to Iron Gate Reservoir)

#### Lower Klamath Basin

- Iron Gate Dam to Salmon River
- Salmon River to Klamath Estuary
- Klamath Estuary
- Marine nearshore

Table 3.2-1 lists the river mile (RM) locations of the above reaches and of features relevant to the water quality area of analysis.

**Table 3.2-1. Location of Klamath Basin Features Relevant to the Water Quality Area of Analysis**

Feature	River Mile <sup>1</sup>
<b>Upper Klamath Basin</b>	
Wood River	282.3+
Williamson, and Sprague rivers	272.3+
Upper Klamath Lake/Agency Lake	254.3 to 282.3
Link River Dam	253.7
Keno Impoundment (including Lake Ewauna)	233.0 to 253 (Lake Ewauna ≈247 to 253)
Keno Impoundment at Miller Island	246
Klamath Straits Drain (at Pumping Plant F)	240.5
J.C. Boyle Reservoir	224.7 to 228.3
Oregon-California state line	208.5
Copco 1 Reservoir	198.6 to 203.1
Copco 2 Reservoir	198.3 to 198.6
Iron Gate Reservoir	190.1 to 196.9
<b>Lower Klamath Basin</b>	
Klamath River confluence with Shasta River	176.7
Klamath River confluence with Scott River	143.0
Seiad Valley	129.4
Klamath River confluence with Salmon River	66.0
Hoop Valley Tribe	≈45 to 46
Weitchpec	43.5
Klamath River confluence with Trinity River	42.5
Klamath River at Turwar	5.8
Klamath Estuary	0 to ≈2

Notes:

<sup>1</sup>. River Mile (RM) refers to distance upstream from the mouth of the Klamath River.

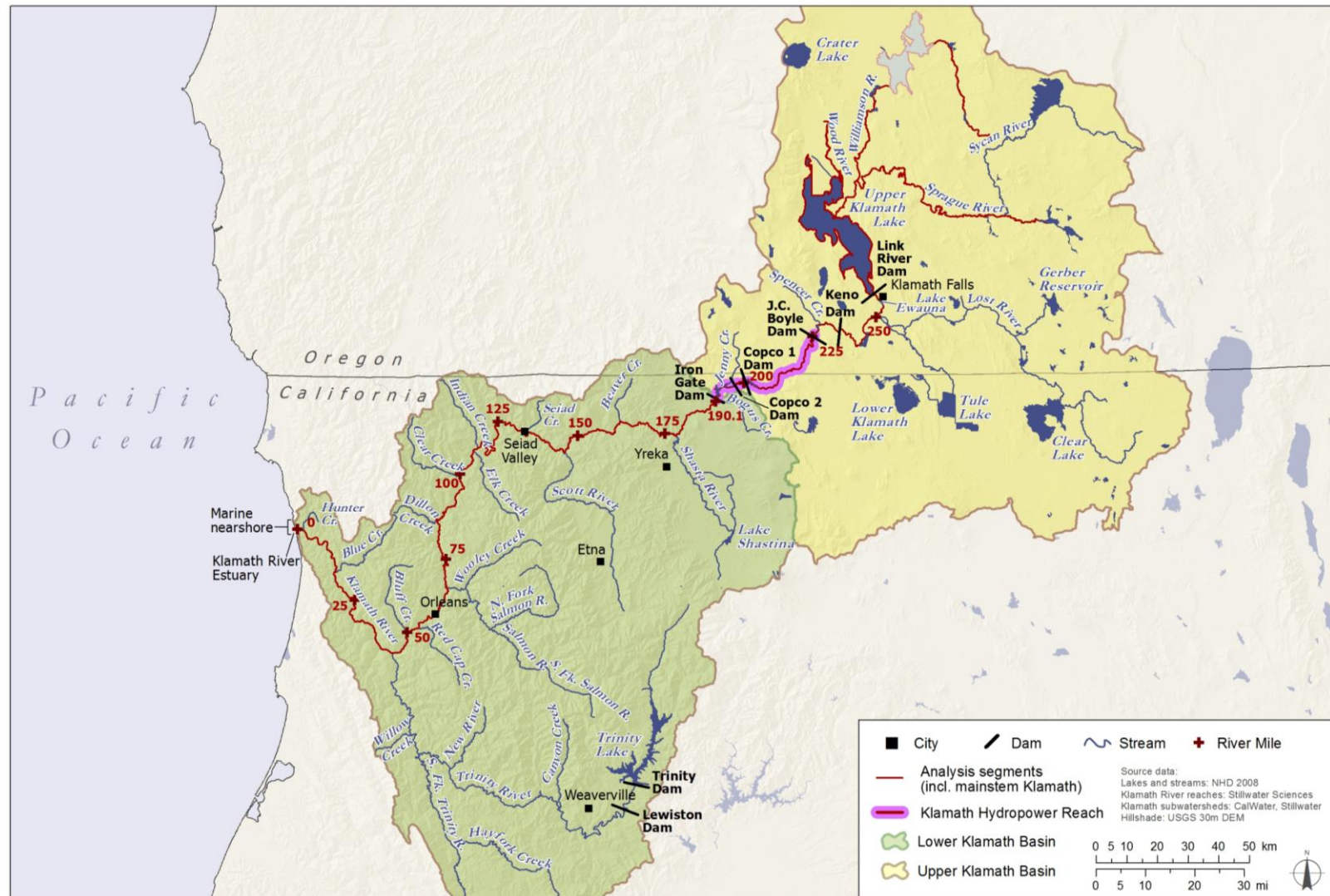


Figure 3.2-1. Water Quality Area of Analysis

### 3.2.2 Regulatory Framework

Multiple federal, state, and tribal programs and planning documents are applicable to the regulation and protection of water quality in the area of analysis, including but not limited to the following:

- Clean Water Act (Title 33 U.S.C. §1313 [1972])
- Safe Drinking Water Act (Title 42 U.S.C. Chapter 6A §300f-j [1973 as amended])
- Oregon Administrative Rules for Water Pollution Control (OAR 340-041)
- North Coast Region Basin Plan (as required by Sections 13240–13247 of Porter-Cologne Water Quality Act)
- Hoopa Valley Tribe Water Quality Control Plan
- Coastal Zone Management Act
- California Ocean Plan (C.W.C. §13170.2)

#### 3.2.2.1 Designated Beneficial Uses of Water

Beneficial uses of water are designated by the Oregon Department of Environmental Quality (ODEQ), the State and Regional Water Quality Control Boards, and the Hoopa Valley Tribe. Other tribal water quality programs, including the development and adoption of beneficial uses, are underway by the Karuk Tribe, the Resighini Rancheria, and the Yurok Tribe. These tribes have not yet completed processes for United States Environmental Protection Agency (USEPA) approved delegation under the Clean Water Act (CWA) (North Coast Regional Water Quality Control Board [NCRWQCB] 2010a). Approved beneficial uses within the area of analysis are presented below (Table 3.2-2).

**Table 3.2-2. Designated Beneficial Uses of Water in the Area of Analysis**

Upper Klamath Lake and Tributaries and Klamath River in Oregon (Oregon Department of Environmental Quality [ODEQ] OAR 340-41-0180)	Klamath River in California (North Coast Regional Water Quality Control Board 2006a)	Hoopa Valley Tribe Beneficial Uses (Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008)	Ocean Plan Beneficial Uses (State Water Resources Control Board [SWRCB] 2001)
Aesthetics and Cultural			
Aesthetic Quality	N/A	Wild and Scenic (W&S)	N/A <sup>1</sup>
N/A	Native American Culture (CUL)	Ceremonial and Cultural Water Use (CUL)**	N/A
Agricultural Water Supply			
Irrigation	Agricultural Supply (AGR)	Agricultural Supply (AGR)*	N/A
Livestock Watering			
Commercial			
Fishing	Commercial and Sport Fishing (COMM)	N/A	Commercial and Sport Fishing (COMM)

**Table 3.2-2. Designated Beneficial Uses of Water in the Area of Analysis**

Upper Klamath Lake and Tributaries and Klamath River in Oregon (Oregon Department of Environmental Quality [ODEQ] OAR 340-41-0180)	Klamath River in California (North Coast Regional Water Quality Control Board 2006a)	Hoopa Valley Tribe Beneficial Uses (Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008)	Ocean Plan Beneficial Uses (State Water Resources Control Board [SWRCB] 2001)
N/A	Shellfish Harvesting (SHELL)	N/A	Shellfish Harvesting (SHELL)
N/A	Aquaculture (AQUA)	N/A	N/A
Fish & Wildlife			
Fish & Aquatic Life <sup>2</sup>	Warm Freshwater Habitat (WARM)	N/A	N/A
	Cold Freshwater Habitat (COLD)	Cold Freshwater Habitat (COLD)	N/A
	Migration of Aquatic Organisms (MIGR)	Migration of Aquatic Organisms (MIGR)	Migration of Aquatic Organisms (MIGR)
	Spawning, Reproduction, and/or Early Development (SPWN)	Spawning, Reproduction, and/or Early Development (SPWN)	Fish Spawning (SPAWN)
N/A	Estuarine Habitat (EST)	N/A	N/A
N/A	Marine Habitat (MAR)	N/A	Marine Habitat (MAR)
Wildlife & Hunting	Wildlife Habitat (WILD)	Wildlife Habitat and Endangered Species (WILD)	N/A
N/A	N/A	N/A	Preservation and Enhancement of Designated Areas of Special Biological Significance (BIOL)
N/A	Rare, Threatened, or Endangered Species (RARE)	Preservation of Threatened and Endangered Species (T&E)	Rare and Endangered Species (RARE)
Potable Water Supply			
Public Domestic Water Supply	Municipal and Domestic Supply (MUN)	Municipal and Domestic Supply (MUN)*	N/A
Private Domestic Water Supply			
Industrial Water Supply			
Industrial Water Supply	Industrial Service Supply (IND)	Industrial Service Supply (IND)	Industrial Water Supply (IND)
	Industrial Process Supply (PROC)	Industrial Process Supply (PROC)	
Hydro Power <sup>3</sup>	Hydropower Generation (POW)	N/A	N/A
Navigation			
Commercial Navigation & Transportation <sup>3</sup>	Navigation (NAV)	N/A	Navigation (NAV)

**Table 3.2-2. Designated Beneficial Uses of Water in the Area of Analysis**

Upper Klamath Lake and Tributaries and Klamath River in Oregon (Oregon Department of Environmental Quality [ODEQ] OAR 340-41-0180)	Klamath River in California (North Coast Regional Water Quality Control Board 2006a)	Hoopa Valley Tribe Beneficial Uses (Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008)	Ocean Plan Beneficial Uses (State Water Resources Control Board [SWRCB] 2001)
<b>Replacement/Recharge</b>			
N/A	Groundwater Recharge (GWR)	Groundwater Recharge (GWR)	N/A
N/A	Freshwater Replenishment (FRSH)	N/A	N/A
<b>Recreation</b>			
Water Contact Recreation	Water Contact Recreation (REC-1)	Water Contact Recreation (REC-1)	Water Contact Recreation (REC-1), including Aesthetic Enjoyment
Boating	Non-contact Water Recreation (REC-2)	Non-contact Water Recreation (REC-2)	Non-contact Water Recreation (REC-2), including Aesthetic Enjoyment

Notes:

<sup>1</sup> See also Recreation REC-2 designation including “aesthetic enjoyment.”

<sup>2</sup> Designated basin-specific beneficial uses for the Klamath Basin (OAR 340-041-0180) include specific fish uses to be protected (i.e., bull trout spawning and juvenile rearing, core cold-water habitat, redband trout, and cool water species [no salmonid use]) and are depicted in Oregon DEQ 2004.

<sup>3</sup> Applicable for mainstem Klamath River from Upper Klamath Lake to Keno Dam (RM 255 to 232.5) (Oregon DEQ 340-041-0180)

Key:

OAR: Oregon Administrative Rules

N/A: Not applicable

\* = Proposed Beneficial Use

\*\* = Historical Beneficial Use

### **3.2.2.2 Water Quality Standards**

#### **3.2.2.2.1 Freshwater**

Water quality standards for fresh surface waters have been established by ODEQ, NCRWQCB, and the Hoopa Valley Tribe to protect the designated beneficial uses listed in Table 3.2-2.

Oregon administrative ruling ORS 468B.025(1) states “...no person shall: (a) Cause pollution of any waters of the state or place or cause to be placed any wastes in a location where such wastes are likely to escape or be carried into the waters of the state by any means; and, (b) Discharge any wastes into the waters of the state if the discharge reduces the quality of such waters below the water quality standards established by rule for such waters by the Environmental Quality Commission.”

The California Porter-Cologne Act defines water quality using chemical, physical, biological, bacteriological, radiological, and other properties and characteristics of water that affect its use. It further defines water quality objectives as the limits or levels of

water quality constituents or characteristics that are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area.

Water quality objectives adopted by the Hoopa Valley Tribe establish water quality objectives for those portions of the Trinity and Klamath rivers under the jurisdiction of the tribe. The Yurok and Karuk Tribes have also adopted water quality objectives, as has the Resighini Rancheria; however, the associated water quality plans have not yet been approved by USEPA (NCRWQCB 2010a, see also discussion regarding tribal beneficial uses in Section 3.2.2.1). Surface-water quality objectives relevant to the Proposed Action and alternatives are listed in Table 3.2-3 through 3.2-7.

**Table 3.2-3. Oregon Surface-Water Quality Objectives Relevant to the Proposed Action and Alternatives.**

<b>Parameter</b>	<b>Criteria/Description<sup>1</sup></b>
Biocriteria OAR 340-041-0011	Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
Dissolved Oxygen OAR 340-041-0016	Sufficient concentrations of dissolved oxygen are necessary to support aquatic life.
	<b>Coldwater aquatic life</b> 8.0 mg/L minimum
	<b>Cool water aquatic life</b> 6.5 mg/L minimum
	<b>Warm water aquatic life</b> 5.5 mg/L minimum
	<b>Spawning</b> 11.0 mg/L minimum
	<b>Spawning</b> 8.0 mg/L minimum intergravel
Nuisance Algae Growth OAR 340-041-0019	Algal growth which impairs the recognized beneficial uses of the water body is not allowed.  For natural lakes that do not thermally stratify, reservoirs, rivers and estuaries, average chlorophyll-a concentrations at or above 0.015 mg/l identify water bodies where phytoplankton may impair the recognized beneficial uses.
pH OAR 340-041-0021 & OAR 340-041-0185	pH values may not fall outside the range of 6.5–9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department will determine whether the values higher than 8.7 are anthropogenic or natural in origin.  Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria are not in violation of the standard, if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria.
Temperature OAR 340-041-0028 & OAR 340-041-0185	Water temperature must support all life stages of temperature-sensitive aquatic communities.  Natural Conditions Criteria. Where the department determines that the natural thermal potential of all or a portion of a water body exceeds the biologically-based criteria, the natural thermal potential temperatures supersede the biologically-based criteria, and are deemed to be the applicable temperature criteria for that water body.

**Table 3.2-3. Oregon Surface-Water Quality Objectives Relevant to the Proposed Action and Alternatives.**

Parameter	Criteria/Description <sup>1</sup>
	From June 1 to September 30, no NPDES point source that discharges to the portion of the Klamath River designated for cool water species may cause the temperature of the water body to increase more than 0.3°C (0.5°F) above the natural background after mixing with 25% of the stream flow. Natural background for the Klamath River means the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream. This criterion supersedes OAR 340-041-0028(9)(a) during the specified time period for NPDES permitted point sources.
	<b>Salmon/steelhead spawning</b> 13°C (55.4 F)
	<b>Core coldwater habitat</b> 16°C (60.8 F)
	<b>Salmon/trout rearing</b> 18°C (64.4 F)
	<b>Redband trout habitat</b> 20°C (68 F)
	<b>Bull trout spawning and juvenile rearing</b> 12°C (53.6 F)
Turbidity OAR 340-041-0036	Numeric criterion generally prohibits turbidity increases which exceed 10-percent above background. Dredging, Construction or other Legitimate Activities: Permit or certification authorized under terms of CWA Section 401 or 404 (Permits and Licenses, Federal Water Pollution Control Act) or OAR 14I-085-0100 et seq. (Removal and Fill Permits, Division of State Lands), with limitations and conditions governing the activity set forth in the permit or certificate.
Toxic material OAR 340-041-0033	Toxic substances may not be introduced above natural background levels in waters of the state in amounts, concentrations, or combinations that may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety, or welfare or aquatic life, wildlife, or other designated beneficial uses) Levels of toxic substances may not exceed the criteria listed in Table 20 [from the OAR] and the new Table 40 <sup>2</sup>

Source: Oregon DEQ (OAR 340-041).

<sup>1</sup> Relevant beneficial uses are shown in bold and all caps. If no beneficial use is specified, the objective or criteria applies to all beneficial uses.

<sup>2</sup> On June 16, 2011, Oregon DEQ revised human health criteria for toxic pollutants using a fish consumption rate of 175 grams per day, which is based on tribal consumption rates for tribes that live in Oregon. The new criteria will be applicable for purposes of the Clean Water Act following approval by USEPA. This section also applies to the revised iron, manganese, and arsenic criteria the commission adopted in December 2010 and April 2011, respectively.



**Table 3.2-4. California Surface-Water Quality Objectives**

Parameter	Description <sup>1</sup>
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
Turbidity	Turbidity shall not be increased more than 20% above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.
Temperature	<b>COLD, WARM</b> (for nontidal waters) The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the NCRWQCB that such alteration in temperature does not adversely affect beneficial uses. The temperature of any cold or warm freshwater habitat shall not be increased by more than 2.8°C (5°F) above natural receiving water temperature.
Dissolved Oxygen	<b>WARM, MAR, SAL, COLD, SPWN</b> Klamath River Mainstem Specific Water Quality Objectives based on natural receiving water temperatures (see Table 3.2-5 for minimum DO concentrations in mg/L) <ul style="list-style-type: none"> <li>• From Oregon-California state line (RM 208.5) to the Scott River (RM 143), 90% saturation October 1-March 31 and 85% saturation April 1-September 30.</li> <li>• From Scott River (RM 143) to Hoopa Valley Tribe boundary (≈RM 45), 90% saturation year round.</li> <li>• From Hoopa Valley Tribe boundary to Turwar (RM 5.8), 85% saturation June 1-August 31 and 90% saturation September 1-May 31.</li> <li>• For upper and middle Klamath River Estuary (RM 0-2), 80% saturation August 1-August 31, 85% saturation September 1-October 31 and June 1-July 31, and 90% saturation November 1-May 31.</li> <li>• <b>EST</b> For lower Klamath River Estuary (RM 0), DO content shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.</li> </ul>
Biostimulatory Substances	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.
Nitrate – N	<b>MUN</b> 45 mg/L as NO <sub>3</sub> <sup>2</sup>
Nitrate + Nitrite	<b>MUN</b> 10 mg/L as N <sup>3</sup>
pH	The pH shall not be depressed below 6.5 units nor raised above 8.5 units <b>COLD, WARM</b> Changes in normal ambient pH levels shall not exceed 0.2 units within the range specified above. For the Klamath River upstream of Iron Gate Dam, including Iron Gate & Copco reservoirs, and the Klamath River downstream of Iron Gate Dam pH shall not be depressed below 7 units nor raised above 8.5 units.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.

**Table 3.2-4. California Surface-Water Quality Objectives**

<b>Parameter</b>	<b>Description<sup>1</sup></b>
Pesticides	No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no bioaccumulation of pesticide concentrations found in bottom sediments or aquatic life. Waters designated for use as domestic or municipal supply shall not contain concentrations of pesticides in excess of the limiting concentrations set forth in California Code of Regulations, Title 22, Division 4, Chapter 15, Article 4, Section 64444.5 (Table 5), and listed in Table 3-2 of the Basin Plan.
Chemical Constituents	Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Division 4, Article 4, Section 64435 (Tables 2 and 3), and Section 64444.5 (Table 5), and listed in Table 3-2 of the Basin Plan. Waters designated for use as agricultural supply (AGR) shall not contain concentrations of chemical constituents in amounts which adversely affect such beneficial use.

Source: NCRWQCB 2010a unless otherwise noted.

<sup>1</sup> Relevant beneficial uses are shown in bold and all caps. If no beneficial use is specified, the objective or criteria applies to all beneficial uses.

<sup>2</sup> Maximum contaminant level for domestic or municipal supply.

<sup>3</sup> Maximum contaminant level (shall not be exceeded in water supplied to the public) as specified in Table 64431-A (Inorganic Chemicals) of Section 64431, Title 22 of the California Code of Regulations (CCR), as of April 23, 2007.

**Table 3.2-5. Minimum DO Concentrations Based on Percent Saturation Criteria<sup>1</sup> (NCRWQCB 2010a).**

DO Concentrations (mg/L)	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
<b>Stateline to Scott River – 90% October 1 through March 31 and 85% April 1 through September 30</b>												
Stateline	10.4	9.6	8.5	7.6	7.0	6.3	6.3	6.4	6.9	7.8	9.5	10.6
Downstream Copco Dam	10.4	9.6	8.5	7.6	6.9	6.3	6.3	6.4	6.9	7.8	9.5	10.6
Downstream Iron Gate Dam	10.8	9.9	8.8	7.8	7.1	6.5	6.5	6.5	7.1	8.1	9.7	10.9
Upstream Shasta River	10.8	10.0	8.9	7.9	7.1	6.6	6.4	6.4	7.1	7.9	9.6	10.8
Downstream Shasta River	10.8	10.1	9.0	7.9	7.2	6.7	6.5	6.5	7.2	8.0	9.7	10.9
Upstream Scott River	10.9	10.2	9.1	8.1	7.2	6.7	6.4	6.5	7.1	7.9	9.8	10.9
<b>Scott River to Hoopa – 90% all year</b>												
Downstream Scott River	10.8	10.2	9.3	8.7	7.9	7.3	6.9	6.9	7.6	8.0	9.8	10.9
Seiad Valley	10.9	10.2	9.3	8.8	7.8	7.2	6.9	6.9	7.5	7.9	9.9	10.9
Upstream Indian Creek	11.0	10.3	9.4	8.9	8.0	7.3	7.0	7.0	7.5	7.9	9.9	10.8
Downstream Indian Creek	11.0	10.3	9.5	9.0	8.1	7.4	7.0	7.0	7.6	8.0	9.9	10.8
Upstream Salmon River	11.2	10.6	9.8	9.3	8.4	7.5	7.2	7.2	7.7	8.2	10.0	11.0
Downstream Salmon River	11.1	10.6	9.9	9.4	8.5	7.6	7.2	7.2	7.7	8.2	10.0	10.9
<b>Hoopa to Turwar – 90% September 1 through May 31 and 85% June 1 through August 31</b>												
Hoopa	11.0	10.6	10.0	9.5	8.5	7.2	7.0	6.9	7.8	8.3	10.1	11.0
Upstream Trinity River	11.0	10.6	10.0	9.5	8.5	7.2	7.0	6.9	7.8	8.3	10.0	11.0
Downstream Trinity River	10.9	10.6	9.9	9.5	8.6	7.4	7.1	7.0	7.9	8.4	10.0	10.9
Youngsbar	10.9	10.6	9.9	9.5	8.7	7.4	7.1	7.0	7.9	8.4	10.0	10.9
Turwar	10.9	10.5	9.9	9.5	8.6	7.2	6.9	6.8	7.6	8.1	9.8	10.8
<b>Upper and Middle Estuary – 90% November 1 through May 31, 85% September 1 through October 31 and June 1 through July 31, 80% August 1 through August 31</b>												
Upper Estuary	10.9	10.6	10.1	9.5	8.6	7.3	7.1	6.7	7.6	8.0	10.0	10.7
Middle Estuary	10.9	10.6	10.1	9.6	8.6	7.3	7.2	6.8	7.8	8.2	10.1	10.8
<b>Lower Estuary – Narrative Objective</b>												

<sup>1</sup> The "Alternative 3" analysis conducted by the NCRWQCB (2010a) to arrive at the DO concentrations listed in this table is not the same as the Alternative 3 referred to in the Klamath Facilities Removal EIS/EIR. Estimates of site-specific natural temperatures inherent to the DO percent saturation estimates are derived from the T1BSR run of the Klamath TMDL model (NCRWQB 2010a).

**Table 3.2-6. Hoopa Valley Tribe Surface-Water Quality Objectives**

Parameter	Criteria/Description <sup>1</sup>
Ammonia (NH <sub>3</sub> , as mg/L N)	<b>COLD</b> Because ammonia toxicity to fish is influenced by pH, waters designated for the purpose of protection of threatened and endangered fish species in cold freshwater habitat shall meet conditions for ammonia based on maximum one-hour (acute) and 30-day average (chronic) concentrations linked to pH by a formula (HVTEPA 2008).
Periphyton	150 mg chlorophyll-a /m <sup>2</sup>
Dissolved oxygen <sup>2</sup>	<b>COLD</b> 8.0 mg/L minimum
	<b>SPWN</b> 11.0 mg/L minimum
	<b>SPWN</b> 8.0 mg/L minimum in inter-gravel water
Total Nitrogen (TN) <sup>3,4</sup>	0.2 mg/L
Total Phosphorous (TP)	0.035 mg/L
pH	The pH in the Klamath River shall be between 7.0 and 8.5 at all times
Microcystis aeruginosa cell density	<b>MUN, REC-1</b> <5,000 cells/mL for drinking water <40,000 cells/mL for recreational water
Microcystin toxin Concentration	<b>MUN, REC-1</b> <1µg/L total microcystins for drinking water <8 µg/L total microcystins for recreational water
Total potentially toxigenic cyanobacteria species <sup>5</sup>	<b>MUN, REC-1</b> <100,000 cells/mL for recreational water
Cyanobacterial scums	<b>MUN, REC-1</b> There shall be no presence of cyanobacterial scums
Nitrate	<b>MUN</b> 10 mg/L

Source: HVTEPA (2008)

<sup>1</sup> Relevant beneficial uses are shown in bold and all caps. If no beneficial use is specified, the objective or criteria applies to all beneficial uses.

<sup>2</sup> HVTEPA (2008) includes a natural conditions clause stating "If dissolved oxygen standards are not achievable due to natural conditions, then the COLD and SPAWN standard shall instead be dissolved oxygen concentrations equivalent to 90% saturation under natural receiving water temperatures." USEPA has approved the Hoopa Valley Tribe definition of natural conditions; the provision that site-specific criteria can be set equal to natural background and the procedure for defining natural background have not been finalized as of June 2011.

<sup>3</sup> HVTEPA (2008) includes a natural conditions clause stating "If total nitrogen and total phosphorus standards are not achievable due to natural conditions, then the standards shall instead be the natural conditions for total nitrogen and total phosphorus." USEPA has approved the Hoopa definition of natural conditions; the provision that site-specific criteria can be set equal to natural background and the procedure for defining natural background have not been finalized as of June 2011.

<sup>4</sup> 30-day mean of at least two sample per 30-day period.

<sup>5</sup> Includes: *Anabaena*, *Microcystis*, *Planktothrix*, *Nostoc*, *Coelosphaerium*, *Anabaenopsis*, *Aphanizomenon*, *Gloeotrichia*, and *Oscillatoria*.

### **3.2.2.2.2 Marine**

Narrative and numeric water quality objectives to support designated beneficial uses under the Ocean Plan are listed below in Table 3.2-7.

**Table 3.2-7. California Marine Water Quality Objectives Relevant to the Proposed Action and Alternatives.**

<b>Water Quality Objective<sup>1</sup></b>	<b>Description</b>
Physical Characteristics	<ul style="list-style-type: none"> <li>Floating particulates and grease and oil shall not be visible.</li> <li>The discharge of waste shall not cause aesthetically undesirable discoloration of the ocean surface.</li> <li>Natural light shall not be significantly reduced at any point outside the initial dilution zone as the result of the discharge of waste.</li> <li>The rate of deposition of inert solids and the characteristics of inert solids in ocean sediments shall not be changed such that benthic communities are degraded.</li> </ul>
Chemical Characteristics	<ul style="list-style-type: none"> <li>The dissolved oxygen concentration shall not at any time be depressed more than 10% from that which occurs naturally, as the result of the discharge of oxygen demanding waste materials.</li> <li>The pH shall not be changed at any time more than 0.2 units from that which occurs naturally.</li> <li>The dissolved sulfide concentration of waters in and near sediments shall not be significantly increased above that present under natural conditions.</li> <li>The concentration of substances set forth in Chapter II, Table B (SWRCB 2001), in marine sediments shall not be increased to levels which would degrade indigenous biota. The concentration of organic materials in marine sediments shall not be increased to levels that would degrade marine life.</li> <li>Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota.</li> <li>Numerical Water Quality Objectives for discharges are listed in California State Water Resources Control Board (SWRCB) (2001), including objectives for the protection of marine aquatic life (i.e., metals, inorganics, organics, chronic and acute toxicity, pesticides and PCBs, radioactivity) and objectives for the protection of human health (noncarcinogenic and carcinogenic compounds).</li> </ul>

Source: SWRCB (2001) unless otherwise noted.

<sup>1</sup> WQOs for bacterial characteristics and elevated temperature (thermal) wastes are not included, as these water quality parameters are not anticipated to be affected by the Project.

### **3.2.2.3 Water Quality Impairments**

Section 303(d) of the CWA requires states to identify water bodies that do not meet water quality objectives and are not supporting their designated beneficial uses. These water bodies are considered to be impaired with respect to water quality. ODEQ and NCRWQCB have both included the Klamath Basin and specifically, the Klamath and Lost Rivers on their CWA Section 303(d) lists of water bodies with water quality impairments (see Table 3.2-8).

**Table 3.2-8. Water Quality Impaired Water Bodies within the Area of Analysis**

Water Body Name	Water Temperature	Sedimentation	pH	Organic Enrichment/ Low Dissolved Oxygen	Nutrients	Ammonia	Chlorophyll-a	Microcystin
<b>Oregon<sup>1</sup></b>								
Sprague River and tributaries	X <sup>s</sup>		X <sup>s</sup>	X <sup>s</sup>				
Williamson River and tributaries	X							
Upper Klamath Lake and Agency Lake			X	X			X	
Upper Klamath River (Keno Dam to Link River Dam, including Keno Impoundment and Lake Ewauna)			X <sup>s</sup>	X <sup>sp,s,f,w (2)</sup>		X <sup>sp,s,f,w</sup>	X <sup>s</sup>	
Upper Klamath River Oregon-California state line to Keno Dam (including J.C. Boyle Reservoir) <sup>(3)</sup>	X <sup>sp,s,f,w (4)</sup>			X <sup>sp,s,f,w (2)</sup>				
<b>California</b>								
Middle Klamath River Oregon-California state line to Iron Gate Dam (including Copco Lake Reservoir [1 and 2] and Iron Gate Reservoir)	X			X	X			X
Middle Klamath River Iron Gate Dam to Scott River Reach <sup>5</sup>	X			X	X			X
Shasta River	X			X				
Scott River	X	X						
Salmon River	X							
Middle and Lower Klamath River Scott River to Trinity River Reach <sup>6</sup>	X			X	X			X
Lower Klamath River-Trinity River to Mouth	X	X		X	X			

Notes:

<sup>1</sup> Oregon lists specific reaches of the Klamath River by river mile and includes specific seasons, in some cases (Kirk et al. 2010).

<sup>2</sup> Listed for dissolved oxygen only (non-spawning) (Kirk et al. 2010).

<sup>3</sup> Oregon defines particular river miles for their listings.

<sup>4</sup> Non-spawning (Kirk et al. 2010).

<sup>5</sup> Selected minor tributaries to the Middle and Lower Klamath River that are impaired for sediment and sedimentation include Beaver Creek, Cow Creek, Deer Creek, Hungry Creek, and West Fork Beaver Creek (USEPA 2010a).

<sup>6</sup> Minor tributaries to the Middle and Lower Klamath River that are impaired for sediment and sedimentation include China Creek, Fort Goff Creek, Grider Creek, Portuguese Creek, Thompson Creek, and Walker Creek (USEPA 2010a).

Key:

Sp = Listed for spring season  
S = Listed for summer season  
F = Listed for fall season  
W = Listed for winter season

### 3.2.2.4 Total Maximum Daily Loads

For water quality impaired water bodies (i.e., 303[d]-listed water bodies), Total Maximum Daily Loads (TMDLs) must be developed by the state with jurisdiction over the water body to protect and restore beneficial uses of water. TMDLs (1) estimate the water body's capacity to assimilate pollutants without exceeding water quality standards; and, (2) set limits on the amount of pollutants that can be added to a water body while still protecting identified beneficial uses. ODEQ and the NCRWQCB cooperated on the development of TMDLs for the impaired water bodies of the Klamath Basin (see Table 3.2-8). Table 3.2-9 lists the status of TMDLs in the Klamath Basin. Table 3.2-9 is followed by a brief narrative summary of TMDLs for each water body to provide relevant context for TMDL-related discussions in Section 3.2.4.3, Effects Determinations. Additional information regarding the Oregon TMDLs can be found on ODEQ's website (<http://www.deq.state.or.us/WQ/TMDLs/klamath.htm>) and for the California TMDLs on the North Coast Regional Water Quality Control Board website ([http://www.swrcb.ca.gov/northcoast/water\\_issues/programs/tmdls/index.shtml](http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/index.shtml)).

**Table 3.2-9. Status of TMDLs in the Klamath Basin**

Water Body	Pollutant/Stressor	Agency	Original Listing Date	TMDL Completion Date <sup>1</sup>
<b>Oregon</b>				
Upper Klamath Lake Drainage	Temperature, dissolved oxygen, and pH	ODEQ	1998	2002
Upper Klamath and Lost Rivers	Temperature, dissolved oxygen, pH, ammonia toxicity, and chlorophyll-a	ODEQ	1998	2011
<b>California</b>				
Lower Lost River <sup>2</sup>	pH and nutrients	USEPA	1992	2008
Klamath River	Temperature, organic enrichment/low dissolved oxygen, nutrient, and microcystin	NCRWQCB	1996, 1998, 2006, and 2008	2010
Shasta River	Temperature and dissolved oxygen	NCRWQCB	1998 and 2008	2007
Scott River	Temperature and sediment	NCRWQCB	1992, 1996, and 1998	2006
Salmon River	Temperature	NCRWQCB	1996	2005
Trinity	Sediment	USEPA	1994 and 2006	2001
South Fork Trinity	Sediment	USEPA	1994 and 2002	1998

Notes:

<sup>1</sup> The TMDL completion date is the year the USEPA approved or is expected to approve the TMDL.

<sup>2</sup> The Upper Lost River upstream of the Oregon border, Clear Lake Reservoir, and tributaries are listed for water temperature and nutrients. In 2004, North Coast Regional Board staff completed an analysis of beneficial uses and water quality conditions in the Upper Lost River watershed and concluded that the listing is not warranted.

Key:

TMDL: Total Maximum Daily Load

ODEQ: Oregon Department of Environmental Quality

USEPA: U.S. Environmental Protection Agency

NCRWQCB: North Coast Regional Water Quality Control Board

#### **3.2.2.4.1 Upper Klamath Lake Drainage TMDLs**

The Upper Klamath Lake TMDLs cover temperature, dissolved oxygen, and pH. The geographic extent of the Upper Klamath Lake TMDLs includes the northern portion of the Upper Klamath Basin, which comprises three sub-basins (i.e., Upper Klamath Lake, Williamson River, and Sprague River). TMDL targets were developed for (1) TP loading as the primary method of improving pH and dissolved oxygen conditions in Upper Klamath and Agency Lakes; (2) heat loads for anthropogenic and background nonpoint sources throughout the basin; (3) dissolved oxygen in the Sprague River (USEPA 1987); and, (4) pH in the Sprague River. Specific implementation actions, including designated Best Management Practices (BMPs), are under development by the designated management agencies (DMAs) (ODEQ 2002).

#### **3.2.2.4.2 Upper Klamath River and Lost River TMDLs**

The Upper Klamath River and Lost River TMDLs cover temperature, dissolved oxygen, pH, ammonia toxicity, and chlorophyll-*a*. ODEQ approved the Upper Klamath and Lost River subbasins TMDLs in December 2010 and USEPA is expected to approve these TMDLs in 2011 (S. Kirk, pers. comm., 9 March 2011). The TMDLs cover the southern portion of the Upper Klamath Basin including (1) the Klamath River from Upper Klamath Lake to the Oregon-California state line and (2) impounded and riverine sections of the Lost River from the state line downstream of the Malone Dam to the state line upstream of Tule Lake, and the Klamath Straits Drain from the state line to the confluence with the Klamath River. The TMDLs require reductions in phosphorus, nitrogen, and biochemical oxygen demand (BOD) loading from both point sources and nonpoint sources in the Upper Klamath River, as well as augmentation of dissolved oxygen in the impoundments. There are no permitted point sources of elevated water temperatures for these TMDLs. The heat load allocation for nonpoint sources is equivalent to 0.2°C (0.4 F) above applicable criteria. Once the TMDLs are final, specific implementation actions, including designated BMPs, will be developed by the DMAs (Kirk et al. 2010).

#### **3.2.2.4.3 Lower Lost River TMDLs**

The Lower Lost River TMDLs cover pH and nutrients. The geographic extent of the Lower Lost River TMDLs in California includes the Lost River from the Oregon-California state line near Anderson-Rose Dam to the Klamath Straits Drain at the Oregon-California state line, including the Tule Lake and Lower Klamath National Wildlife Refuge areas. Water from the Lower Lost River can be diverted into the Klamath River via the Lost River Diversion Dam and the Klamath Straits Drain (after passing through Tule Lake, the P Canal system, and, in some cases, the Lower Klamath National Wildlife Refuge). The TMDLs were designed to ensure that California's numeric dissolved oxygen water quality standard would be attained in the Lower Lost River. Implementation measures focus on water quality effects from Reclamation's Klamath Project, the U.S. Fish and Wildlife Service (USFWS) Klamath Refuges, and the Tulelake Wastewater Treatment Plant (USEPA 2008).



#### **3.2.2.4.4 Klamath River TMDLs**

The Klamath River TMDLs cover temperature, organic enrichment/low dissolved oxygen, nutrient, and microcystin. The geographic extent of the California Klamath River TMDL analyses includes the river from state line to the Pacific Ocean. The TMDLs do not specifically address existing sedimentation/siltation impairments in the Klamath River from the Trinity River to the Pacific Ocean; currently, sediment TMDLs for the Trinity and South Fork Trinity Rivers address these impairments. Additionally, the Action Plans do not cover tribal lands. The TMDLs assign three load allocations to the Klamath Hydroelectric Project (KHP) in California (NCRWQCB 2010a):

- Create a compliance lens in Copco and Iron Gate Reservoirs, such that water temperature and dissolved oxygen conditions are suitable for cold water fish during the critical summer period.
- Annual TP and TN loading reduction (TP=22,367 lbs and TN=120,577 lbs) to offset the reduced nutrient assimilative capacity in the reservoirs (as compared to a free-flowing river condition) that is associated with nuisance blooms of green algae and cyanobacteria in the reservoirs. TMDL targets are established for chlorophyll-*a*, *Microcystis aeruginosa* cell density, and microcystin.
- Daily average (and daily maximum) increase in water temperatures relative to inflow temperatures for reservoir tailrace waters (0.1°C [0.18°F] for Iron Gate and 0.5°C [0.9°F] for Copco 1 and 2).

The first two load allocations include a provision for the use of reservoir management measures to achieve the TMDL targets. Numerous implementation actions are described in NCRWQCB (2010b).

#### **3.2.2.4.5 Shasta River TMDLs**

The Shasta River TMDLs for temperature and dissolved oxygen cover the Shasta River, a tributary to the mainstem Klamath River, located in the central portion of the Lower Klamath Basin. The TMDL extends from the headwaters to the confluence with the Klamath River, and includes tributaries to the Shasta River and Lake Shastina. Implementation actions build upon ongoing watershed restoration and enhancement work (e.g., increasing riparian vegetation to decrease water temperature and improve bank stability; controlling tailwater discharges to prevent the release of elevated temperature and nutrient enriched waters; promoting efficient water use to increase dedicated cold water flow; addressing proximal land use activities that contribute to low dissolved oxygen and high water temperatures in the watershed, such as timber harvest and road building) (NCRWQCB 2006b, 2007).

#### **3.2.2.4.6 Scott River TMDLs**

The Scott River TMDL for temperature and sediment covers the Scott River, a tributary to the mainstem Klamath River, located in the central portion of the Lower Klamath Basin. The TMDL extends from the headwaters of the Scott River to its confluence with the mainstem Klamath River. Implementation of the Scott River TMDL is expected to achieve water quality standards for water temperature and sediment within 40 years of plan approval. Implementation actions include the following (NCRWQCB 2007):

- Controlling road-caused sediment;
- Reviewing dredge mining effects;
- Promoting the preservation of riparian vegetation and regulating its suppression and/or removal;
- Implementing water conservation practices;
- Studying groundwater uses and effects;
- Ensuring flood control and bank stabilization activities
- Minimizing vegetation removal/suppression and sediment delivery;
- Regulating discharges related to timber harvest; and,
- Minimizing the effect of grazing.

#### **3.2.2.4.7 Salmon River TMDL**

The Salmon River TMDL for temperature covers the Salmon River, a tributary to the mainstem Klamath River located in the southern portion of the Lower Klamath Basin. The Salmon River TMDL target for water temperature applies throughout the Salmon River watershed and is necessary to achieve the Basin Plan water quality objective for temperature. The Basin Plan criterion requires no alteration of temperature without demonstrations that an increase will not adversely affect beneficial uses nor may the temperature of any cold water be increased by more than 5°F above natural receiving temperature (NCRWQCB 2005).

#### **3.2.2.4.8 Trinity River TMDL**

The Trinity River TMDL for sediment covers the portions of the mainstem Trinity River watershed governed by California water quality standards (i.e., not lands under tribal jurisdiction) in the southern portion of the Lower Klamath Basin, to the confluence of the Trinity and Klamath rivers; the TMDL does not apply to the South Fork Trinity River. The Trinity River TMDL target for sediment is a set loading capacity of 125 percent of the background sediment delivery rate (USEPA 2001). Examples of ongoing implementation actions include, but are not limited to, completing watershed and road analyses in United States Forest Service (USFS) and Bureau of Land Management (BLM) lands, watershed restoration, limiting suction dredge operations, comprehensive aquatic monitoring, improving Timber Harvest Plan (THP)s, and continued road/erosion control and fuels management.

#### **3.2.2.4.9 South Fork Trinity River TMDL**

The South Fork Trinity River TMDL for sediment covers the South Fork Trinity River from its headwaters in the North Yolla Bolly Mountains in the southern portion of the Lower Klamath Basin, to the confluence with the Trinity River, and includes Hayfork Creek and other smaller tributaries. The TMDL for sediment is approximately 737 tons per square mile per year. Ongoing implementation actions include encouraging landowner-based sediment reduction plans, specifying requirements for sediment reduction plans, and providing alternative land management guidelines (USEPA 1998). Additional actions include developing a monitoring process for the basin.

### 3.2.3 Existing Conditions/Affected Environment

#### 3.2.3.1 Overview of Water Quality Processes in the Klamath Basin

Water quality in the Klamath River is affected by the geology and meteorology of the Klamath Basin, as well as current and historical land- and water-use practices. Cold air temperatures and precipitation generally occur from November to March (see Section 3.6, Flood Hydrology), corresponding to periods of higher flows and colder water temperatures. Warmer air temperatures and drier conditions occur from April to October (see Section 3.6, Flood Hydrology), corresponding to periods of lower flows and warmer water temperatures. The relatively low relief, volcanic terrain of the upper Klamath Basin (see Section 3.11, Geology, Soils, and Geologic Hazards) supports large, shallow natural lakes (Upper Klamath Lake, Agency Lake, Tule Lake, Lower Klamath Lake) and wetlands, with soils that are naturally high in phosphorus. Human activities in the upper basin, including wetland draining, agriculture, ranching, logging, and water diversions have altered seasonal stream flows and water temperatures, increased concentrations of nutrients (nitrogen and phosphorus) and suspended sediment in watercourses, and degraded other water quality parameters such as pH and dissolved oxygen concentrations. The lower Klamath Basin is composed of generally steeper, mountainous terrain (see Section 3.11, Geology, Soils, and Geologic Hazards), where historical hillslope and in-channel gold mining and extensive logging have occurred, along with agricultural and ranching activities that divert water in many of the lower tributary basins. These activities have altered streamflows, increased concentrations of suspended sediment and nutrients in watercourses, and increased summer water temperatures.

The presence and operation of the Four Facilities in the Klamath Hydroelectric Reach of the upper Klamath Basin affect many aspects of water quality in the Klamath River. The most common effects of hydroelectric projects on water quality result from changes in the physical structure of the aquatic ecosystem. Dams slow the transport of water downstream, intercept and retain sediment, organic matter, nutrients, and other constituents that would otherwise be transported downstream, as well as alter seasonal water temperatures when compared to free-flowing stream reaches.

- **River and reservoir water temperatures.** The primary effects of hydroelectric project operations on the natural temperature regime of streams and rivers are related to alterations in water surface area, depth, and velocity due to water diversions into or out of the stream corridor, including reservoir impoundments and conveyance through pipelines or penstocks. These changes influence the amount of heat entering and leaving water bodies (such as from solar radiation and nighttime re-radiation), which determines the water temperature. Because reservoirs are often deep, they can retain their water temperature for weeks or months, thereby shifting the natural water temperature patterns below reservoirs. For example, water released from reservoirs in the springtime is typically cooler than would naturally occur because the reservoir retains some of the cold water it received in the winter. Similarly, water released from reservoirs in the fall is typically warmer than would naturally occur because the reservoir still contains water that was heated during the summer months. Additionally, due to surface

heating of the reservoir in the late spring and summer, a warmer, less dense water layer forms on the reservoir surface (the epilimnion), which overlies colder, denser water (the hypolimnion). This process is called thermal stratification and often persists for months.

- **Reservoir mixing and dissolved oxygen.** The water column in most deep reservoirs has a characteristic thermal and chemical structure that is independent of the size of the reservoir. With thermal stratification (in summer and fall), the isolated deeper water is not exposed to the atmosphere and often completely loses its supply of dissolved oxygen over a period of weeks or months as organic matter in bottom sediments decays. Releases of this deeper, oxygen-depleted water from the bottom of the reservoir can cause serious problems for downstream fish and other aquatic biota. In the fall, thermal stratification typically breaks down as the surface layer cools and wind mixing of the water column occurs. This process is called reservoir turnover.
- **Algae in reservoirs.** Because large reservoirs have long retention times for water and thermally stratify in the summer months, they often provide ideal conditions for the growth of suspended algae (phytoplankton) in the epilimnion. Depending upon available nutrients, extensive phytoplankton blooms can develop in these reservoirs. Algal photosynthesis during the day releases dissolved oxygen and consumes carbon dioxide. At night, algal respiration consumes dissolved oxygen and releases carbon dioxide. This can result in wide swings in dissolved oxygen and pH, which is stressful to aquatic biota. Under nutrient-rich conditions, harmful blooms of blue-green algae can occur, producing cyanotoxins (e.g., cyclic peptide toxins that act on the liver such as microcystin, alkaloid toxins such as anatoxin-a and saxitoxin that act on the nervous system). Cyanotoxins have been found to be harmful to a wide range of biota including exposed fish, shellfish, livestock, and humans. Releases of impounded waters can transport algae and/or toxins to downstream waters and algal blooms can die abruptly (“crash”), releasing cyanotoxins into the water column. The subsequent decomposition of organic matter associated with algal remains can create periods of low dissolved oxygen in reservoir bottom waters.
- **Nutrient cycling in reservoirs and internal loading.** Nutrients entering reservoirs can undergo many changes and be involved in many biochemical processes. On an annual basis, the majority of nutrients entering a reservoir from a watershed are eventually discharged downstream, with only a small fraction being retained in the reservoir bottom sediments. Dissolved nutrients (e.g., ortho-phosphorus, nitrate, and ammonium) entering a reservoir can be used directly by algae when growing conditions are good. Some of these algae eventually die and settle to the bottom of reservoirs, also contributing nutrients (and organic matter) to the bottom sediments. Under low oxygen conditions, nutrients contained within bottom sediments can be re-released to the water column, creating a source of internal nutrient loading to the reservoir. This is particularly important for phosphorus and results in highly enriched bottom waters during periods of reservoir stratification. At turnover, these nutrient rich waters are mixed throughout the reservoir, can be released downstream, and can result in a secondary (fall) algae bloom.

- **Sediment deposition in reservoirs.** The characteristically slow-moving waters in reservoirs result in trapping of deposition of fine sediments and organic particulate matter. Contaminants found in the bottom sediments of reservoirs are typically transported from the watershed in association with particulate matter. Trace metals are mostly attached to (inorganic) clays and silts. Organic contaminants, such as pesticides and dioxin, are attached (adsorbed) to organic matter.

The following sections summarize general water quality trends by parameter in the Klamath River, from the upper basin to the lower basin. Additional detail, including data from multiple agency and tribal monitoring programs throughout the Klamath Basin, is presented in Appendix C.

### **3.2.3.2 Water Temperature**

Water temperatures in the Klamath Basin vary seasonally and by location. In the Upper Klamath Basin, water temperatures are typically very warm in summer months as ambient air temperatures heat surface waters. Water temperatures (measured as 7-day-average maximum values) in Upper Klamath Lake and much of the reach from Link River Dam to the Oregon-California state line exceed 20°C (68°F) in June through August. Both Upper Klamath Lake and the Keno Impoundment undergo periods of intermittent, weak summertime stratification, but water temperatures in these water bodies are generally similar throughout the water column and among the warmest in the Klamath Basin (peak values >25°C [>77°F]). Upper basin locations influenced by groundwater springs, such as the Wood River and the mainstem Klamath River downstream of J.C. Boyle Dam, have relatively constant water temperatures year-round and can be 5–15°C (9–27°F) cooler than other local water bodies during summer months, depending on the location.

Water temperatures in the Klamath Hydroelectric Reach are influenced by the presence of the Four Facilities. The relatively shallow depth and short hydraulic residence times in J.C. Boyle Reservoir do not support thermal stratification (Federal Energy Regulatory Commission [FERC] 2007; Raymond 2008, 2009, 2010) and this reservoir does not directly provide a source of cold water to downstream reaches during summer (National Research Council [NRC] 2003). However, current power-peaking operations at the J.C. Boyle Powerhouse contribute to the availability of cold water in the river just downstream of the dam (≈RM 221), where cold groundwater springs enter the river. During daily peaking operations at J.C. Boyle Powerhouse, warm reservoir discharges are diverted from the bypass reach allowing cold groundwater to dominate flows in the river (PacifiCorp 2006a). Water temperatures in the bypass reach can decrease by 5–15°C (9–27°F) when peaking operations are underway (Kirk et al. 2010).

Iron Gate and Copco 1 Reservoirs are the two deepest reservoirs in the Klamath Hydroelectric Reach. These reservoirs thermally stratify beginning in April/May and the surface and bottom waters do not mix again until October/November (Raymond 2008, 2009, 2010). The large thermal mass of the stored water in the reservoirs delays the

natural warming and cooling of riverine water temperatures on a seasonal basis such that spring water temperatures in the Klamath Hydroelectric Reach are generally cooler than would be expected under natural conditions, and summer and fall water temperatures are generally warmer (NCRWQCB 2010a). In the Hydroelectric Reach, maximum weekly maximum temperatures (MWMTs), which generally occur in late July, regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support in California (NCRWQCB 2010a).

The temporal water temperature pattern of the Hydroelectric Reach is repeated in the Klamath River immediately downstream of Iron Gate Dam, where water released from the reservoirs is 1–2.5°C (1.8–4.5°F) cooler in the spring and 2–10°C (3.6–18°F) warmer in the summer and fall as compared to modeled conditions without the dams (PacifiCorp 2004a, Dunsmoor and Huntington 2006, NCRWQCB 2010a). This trend is discussed in more detail in Section 3.2.4.3.2.1, Lower Klamath Basin. Immediately downstream of Iron Gate Dam (RM 190.1), water temperatures are also less variable than those documented farther downstream in the Klamath River (Karuk Tribe of California 2009, 2010).

Farther downstream, the presence of the Four Facilities exerts less influence and water temperatures are more influenced by the natural heating and cooling regime of ambient air temperatures and tributary inputs of surface water. Meteorological control of water temperatures result in increasing temperature with distance downstream of Iron Gate Dam. For example, daily average temperatures between June and September are approximately 1–4°C (1.8–7.2°F) higher near Seiad Valley (RM 129.4) than those just downstream of the dam (Karuk Tribe of California 2009, 2010; see Appendix C for more detail). By the Salmon River (RM 66), the affects of the dams on water temperature are not discernable.

Downstream of the Salmon River (RM 66), summer water temperatures begin to decrease slightly with distance as coastal meteorology (i.e., fog and lower air temperatures) decrease longitudinal warming (Scheiff and Zedonis 2011) and cool water tributary inputs increase the overall flow volume in the river. In general, however, the slight decrease in water temperatures in this reach is not sufficient to support cold water fish habitat during summer months. Daily maximum summer water temperatures have been measured at values greater than 26°C (78.8°F) just upstream of the confluence with the Trinity River (Weitchpec [RM 43.5]), decreasing to 24.5°C (76.1°F) near Turwar Creek (RM 5.8) (Yurok Tribe Environmental Program [YTEP] 2005, Sinnott 2010). As is the case further upstream, MWMTs in the Klamath River downstream of Iron Gate Dam to the Klamath River estuary regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support in California (NCRWQCB 2010a).

Water temperatures in the Klamath River estuary are linked to temperatures and flows entering the estuary, salinity of the estuary and resulting density stratification, as well as the timing and duration of the formation of a sand berm across the estuary mouth. When the estuary mouth is open, denser salt water from the ocean sinks below the lighter fresh

river water, resulting in a salt wedge that moves up and down the estuary with the daily tides (Horne and Goldman 1994, Wallace 1998, Hiner 2006). The salt water wedge results in thermal stratification of the estuary with cooler, high salinity ocean waters remaining near the estuary bottom, and warmer, low salinity river water near the surface. Under low-flow summertime conditions, when the mouth can closed, surface water temperatures in the estuary have been observed at 18–24°C (64.4–75.2°F) and greater (Wallace 1998, Hiner 2006, Watercourse Engineering, Inc. 2011). Input of cool ocean water and fog along the coast minimizes extreme water temperatures much of the time (Scheiff and Zedonis 2011).

### **3.2.3.3 Suspended Sediments**

For the purposes of the Klamath Facilities Removal EIS/EIR, suspended sediment refers to settleable suspended material in the water column. Bed materials, such as gravels and larger substrates, are discussed in Section 3.3.3.2, Aquatic Resources – Existing Conditions/Affected Environment – Physical Habitat Descriptions. Two types of suspended material are important to water quality in the Klamath Basin and are discussed below: algal-derived (organic) suspended material and mineral (inorganic) suspended material. Sources of each type of suspended material differ, as do spatial and temporal trends for each, within the Upper and Lower Klamath Basins.

Suspended sediments in the tributaries to the Upper Klamath Lake are generally derived from mineral (inorganic) materials, with peak values associated with winter and spring high flows. Of the three main tributaries to the Upper Klamath Lake, the Sprague River has been identified as a primary source of sediment to Upper Klamath Lake. Because phosphorus is naturally high in Klamath Basin sediments, the Sprague River is also an important source of this nutrient to the lake (Gearheart et al. 1995, ODEQ 2002, Connelly and Lyons 2007). Sources of the sediment inputs within the Sprague River drainage include agriculture, livestock grazing and forestry activities, and road-related erosion (ODEQ 2002, Connelly and Lyons 2007, Rabe and Calonje 2009).

Between Link River at Klamath Falls (RM 253.1) and the upstream end of J.C. Boyle Reservoir (RM 224.7), algal-derived (organic) suspended material is the predominant form of suspended material affecting water quality. Summer and fall algal-derived (organic) suspended materials decrease with distance downstream, as algae are exported from Upper Klamath Lake and into Lake Ewauna and the Keno Impoundment, where they largely settle out of the water column (Sullivan et al. 2009). Data from June through November during 2000-2005 indicate that the largest relative decrease in mean total suspended solids (TSS) in the upper Klamath River occurs between Link River Dam and Keno Dam (see Appendix C for more detail). Suspended materials generally continue to decrease through the Hydroelectric Reach (PacifiCorp 2004b), where further interception, decomposition, and retention of algal-derived (organic) suspended materials originating from Upper Klamath Lake occurs, as well as dilution from the springs downstream of J.C. Boyle Dam. However, increases in suspended material can occur in Copco 1 and Iron Gate reservoirs due to *in situ* summertime algal blooms, which can adversely affect beneficial uses. In the winter months, suspended material in the Hydroelectric Reach is

dominated by mineral sediment loads transported during high flow events, which can also settle out in the KHP reservoirs (see Appendix C for more detail).

Just downstream of Iron Gate Dam (RM 190.1), summer and fall suspended sediment concentrations become relatively low. Between Iron Gate Dam and Seiad Valley (RM 129.4), suspended materials can increase due to the transport of in-reservoir algal blooms to downstream reaches of Klamath River, as well as river bed scour and resuspension of previously settled materials (YTEP 2005, Sinnott 2007, Armstrong and Ward 2008, Watercourse Engineering, Inc. 2011). Further downstream, near the confluence with the Scott River (RM 143.0) concentrations of suspended materials tend to decrease with distance as suspended materials gradually settle out of the water column farther downstream or are diluted by tributary inputs (see Appendix C for more detail).

Mineral (inorganic) suspended sediments begin to have prominence again in the Klamath River downstream of Iron Gate Dam, as major tributaries to the mainstem contribute large amounts of mineral (inorganic) suspended sediments to the river during winter and spring (Armstrong and Ward 2008). Steeper terrain and land use activities such as timber harvest and road construction result in high sediment loads during high-flow periods. Two of the three tributaries that contribute the largest amount of sediment to the Klamath River are in this reach; the Scott River (RM 143) (607,300 tons per year or 10 percent of the cumulative average annual delivery from the basin), and the Salmon River (RM 66.0) (320,600 tons per year or 5.5 percent of the cumulative average annual delivery from the basin) (Stillwater Sciences 2010). The Trinity River contributes 3,317,300 tons per year of sediment to the Klamath River or 57 percent of the cumulative average annual delivery from the basin (Stillwater Sciences 2010) (see Appendix C for more detail).

#### **3.2.3.4 Nutrients**

Primary nutrients including nitrogen and phosphorus are affected by the geology of the surrounding watershed of the Klamath River, upland productivity and land uses, as well as a number of physical processes affecting aquatic productivity within reservoir and riverine reaches. Nitrogen arriving in Upper Klamath Lake has been attributed to upland soil erosion, runoff and irrigation return flows from agriculture, as well as *in situ* nitrogen fixation by cyanobacteria (ODEQ 2002). Although the relatively high levels of phosphorus present in the Upper Klamath Basin's volcanic rocks and soils have been identified as a major contributing factor to phosphorus loading to the lake (ODEQ 2002), land use activities in the Upper Klamath Basin have also been linked to increased nutrient loading (Kann and Walker 1999, Snyder and Morace 1997; see Appendix C, Section C.3.1.2 for more detail), subsequent changes in its trophic status, and associated degradation of water quality. Extensive monitoring and research has been conducted for development of the Upper Klamath Lake TMDLs (ODEQ 2002) that shows the lake is a major source of nitrogen and phosphorus loading to the Klamath River (see Appendix C for additional details).



Allowing for seasonal reservoir dynamics in the Hydroelectric Reach, nutrient levels in the Klamath River generally decrease with distance downstream of Upper Klamath Lake due to particulate trapping in reservoirs, dilution, and uptake along the river channel. In a recent study of nutrient dynamics in the Klamath River, May through December nutrients for 2005–2008 followed a decreasing longitudinal pattern, with the highest concentrations (approximately 0.1–0.5 mg/L TP and 1–4 mg/L TN) measured in the Klamath River downstream of Keno Dam (RM 228–233) (Asarian et al. 2010). On an annual basis, nutrients typically decrease through the Hydroelectric Reach due to the dilution by the springs downstream of J.C. Boyle Reservoir and settling of particulate matter and associated nutrients in Copco 1 and Iron Gate reservoirs. On a seasonal basis, TP, and to a lesser degree, TN can increase in this reach due to the release (export) of dissolved forms of phosphorus (ortho-phosphorus) and nitrogen (ammonium) from reservoir sediments during periods of summer and fall hypolimnetic anoxia (see Appendix C for additional details). The seasonal nutrient releases can occur during periods of in-reservoir algal growth, or can be transported downstream to the lower Klamath River where they may stimulate periphyton growth.

Downstream of the Four Facilities, TP values typically range 0.1–0.25 mg/L in the Klamath River between Iron Gate Dam and Seiad Valley, with the highest values occurring just downstream of the dam. TN concentrations in the river downstream of Iron Gate Dam generally range from <0.1 to over 2.0 mg/L and are generally lower than those in upstream reaches due to reservoir retention and dilution by springs in the Hydroelectric Reach (Asarian et al. 2009) (see Appendix C for additional details). Further decreases in TN occur in the mainstem river due to a combination of tributary dilution and in-river nitrogen removal processes such as denitrification and/or storage related to biomass uptake (Asarian et al. 2010). Ratios of nitrogen to phosphorus (TN:TP) measured in the Klamath River downstream of Iron Gate Dam suggest the potential for nitrogen-limitation of primary productivity with some periods of co-limitation by both nitrogen and phosphorus. However, concentrations of both nutrients are high enough that other factors (i.e., light, water velocity, or available substrate) may be more limiting to primary productivity than nutrients are, particularly in the vicinity of Iron Gate Dam (FERC 2007, Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008, Asarian et al. 2010) (see Appendix C for additional details). This is particularly important with regard to factors controlling periphyton growth in this portion of the Klamath River (see Section 3.4, Algae).

Downstream of the confluence with the Salmon River, nutrient concentrations continue to decrease in the Klamath River as compared with those measured farther upstream due to tributary dilution and nutrient retention. Contemporary data (2005–2008) indicate that TP concentrations in this reach are generally 0.05–0.1 mg/L with peak values occurring in September and October. For TN, contemporary data indicate that on a seasonal basis, this nutrient increases from May through November, with peak concentrations (<0.5 mg/L) typically observed during September and October. Relative to the higher concentrations measured near Iron Gate Dam, these lower nutrient concentrations may be limiting periphyton growth in this portion of the river. Both TP and TN are at or above

the Hoopa Valley Tribe numeric criterion of 0.2 mg/L TN and 0.035 mg/L TP (see Table 3.2-6).

Nutrient levels in the Klamath Estuary experience inter-annual and seasonal variability. Measured levels of TP in the estuary are typically below 0.1 mg/L during summer and fall (June–September) and TN levels are consistently below 0.6 mg/L (June–September) (Sinnott 2011); however, as with upstream reaches, these levels do not meet the narrative California Basin Plan water quality objective for biostimulatory substances due to the promotion of algal growth at levels that cause nuisance effects or adversely affect beneficial uses (see Table 3.2-4).

### **3.2.3.5 Dissolved Oxygen**

Dissolved oxygen concentrations in the Klamath Basin depend on several factors, including water temperature (colder water absorbs more oxygen), water depth and volume, stream velocity (as related to mixing and re-aeration), atmospheric pressure, salinity, and the activity of organisms that depend upon dissolved oxygen for respiration. This last factor (respiratory consumption) is strongly influenced by the availability of nitrogen and phosphorus for supporting algal and aquatic plant growth.

In tributaries to Upper Klamath Lake, limited data indicate that dissolved oxygen varies from <7–13 mg/L (Kann 1993, ODEQ 2002). Concentrations in the lake itself exhibit high seasonal and spatial variability, ranging from less than 4 mg/L to greater than 10 mg/L. High nutrient loading is the primary cause of eutrophication and subsequent low dissolved oxygen levels in Upper Klamath Lake. Water quality data collected by the Klamath Tribes contains periods of weeks during the summer months when dissolved oxygen levels in the lake are continuously below the ODEQ criterion of 5.5 mg/L for support of warm water aquatic life (Kann et al. 2010). Low (0–4 mg/L) dissolved oxygen concentrations occur most frequently in August, the period of declining algal blooms in the lake and warm water temperatures (ODEQ 2002, Walker 2001) (see Appendix C for additional details).

In the downstream Keno Impoundment (including Lake Ewauna), dissolved oxygen reaches very low levels (< 1–2 mg/L) during July–October as algae transported from Upper Klamath Lake settle out of the water and decay. Four facilities discharge treated wastewater to the Keno Impoundment; however, these facilities contribute a very small amount (<1.5% of the organic material loading) to the overall oxygen demand in the Keno Reach. Decomposition of algae transported from Upper Klamath Lake appears to be the primary driver of low oxygen in the Keno Impoundment (including Lake Ewauna) (Sullivan et al. 2009, et al. 2011; Kirk et al. 2010).

During summer, the reservoirs of the Four Facilities exhibit varying degrees of dissolved oxygen super-saturation (i.e., >100% saturation) in surface waters (due to high rates of internal photosynthesis by algae) and hypolimnetic oxygen depletion in bottom waters (due to microbial decomposition of dead algae). Although J.C. Boyle Reservoir, a relatively long, shallow reservoir, does not stratify, large variations in dissolved oxygen

are observed at its discharge due to conditions in the upstream reach from Link River Dam through the Keno Impoundment (including Lake Ewauna), and in Upper Klamath Lake (see Appendix C for more detail). Copco 1 and Iron Gate Reservoirs thermally stratify beginning in April/May and do not mix again until October/November (FERC 2007). Dissolved oxygen in Iron Gate and Copco 1 surface waters during summer months is generally at or, in some cases above, saturation while levels in hypolimnetic waters reach minimum values near 0 mg/L by July (see Appendix C for more detail).

Based upon measurements collected immediately downstream of Iron Gate Dam, dissolved oxygen concentrations regularly fall below 8 mg/L (the Basin Plan minimum dissolved oxygen criterion is now based on percent saturation, see Table 3.2-5) (Karuk Tribe of California 2001, 2002, 2007, 2009). Continuous Sonde data collected at other Klamath River locations downstream of Iron Gate Dam during summer 2004–2006, show that roughly 45 to 65 percent of measurements immediately downstream of the dam did not achieve 8 mg/L. Daily fluctuations of up to 1–2mg/L measured in the Klamath River downstream of Iron Gate Dam (RM 190.1) have been attributed to daytime algal photosynthesis and nighttime bacterial respiration (Karuk Tribe of California 2002, 2003; YTEP 2005; NCRWQCB 2010a). Farther downstream in the mainstem Klamath River, near Seiad Valley (RM 129.4), dissolved oxygen concentrations increase relative to the reach immediately downstream of Iron Gate Dam, but continue to exhibit variability, with mean daily values ranging from approximately 6.5 mg/L to (supersaturated concentrations of) approximately 10.5 mg/L, from June through November, 2001–2002 and 2006–2009 (Karuk Tribe of California [2001, 2002, 2007, 2009]).

Measured concentrations of dissolved oxygen in the mainstem Klamath River downstream of Seiad Valley (RM 129.4) continue to increase with increasing distance from Iron Gate Dam. Dissolved oxygen concentrations near Orleans (RM 59) continue to be variable, with typical daily values ranging from approximately 6.5 mg/L to (supersaturated concentrations of) 11.5 mg/L from June through November, 2001–2002 and 2006–2009 (Karuk Tribe of California [2001, 2002, 2007, 2009], Ward and Armstrong 2010, NCRWQCB 2010a). Further downstream, near the confluence with the Trinity River (RM 42.5) and at the Turwar gage (RM 5.8), minimum dissolved oxygen concentrations below 8 mg/L (the Basin Plan minimum dissolved oxygen criterion prior to 2010) have been observed for extended periods of time during late summer/early fall (YTEP 2005, Sinnott 2010). In 2010, minimum dissolved oxygen concentrations remained above 2010 amended Basin Plan minimum dissolved oxygen concentration criteria based on percent saturation (see Appendix C for additional details).

Dissolved oxygen concentrations in the Klamath Estuary vary both temporally and spatially; concentrations in the deeper, main channel of the estuary are generally greater than 6 to 7 mg/L throughout the year (Hiner 2006, YTEP 2005). Low dissolved oxygen concentrations (<1 to 5 mg/L) have been observed during summer months in the relatively shallow, heavily vegetated south slough (Hiner 2006, Wallace 1998). The low levels of dissolved oxygen observed in the slough are likely due to high rates of growth and subsequent decomposition of algae and macrophytes, which are not abundant elsewhere in the estuary.

### **3.2.3.6 pH**

Levels of pH in the Klamath Basin vary daily, seasonally, and by location. In the Upper Klamath Basin, summertime pH levels are elevated above neutral (i.e., up to 8.2 in the Wood River subbasin and 8.5–9.5 in the Sprague River). These elevated pH levels have been linked primarily to high rates of photosynthesis by periphyton (i.e., benthic or attached algae) (ODEQ 2002). During November–April, pH levels in Upper Klamath Lake are near neutral (Aquatic Scientific Resources [ASR] 2005) but increase to very high levels (>10) in summer (ODEQ maximum pH is 9.0, see Table 3.2-3). Extended periods of pH greater than 9 have been associated with large summer algal blooms in Upper Klamath Lake (Kann 2010). On a daily basis, algal photosynthesis can elevate pH levels by up to 2 pH units over a 24-hour period. Generally, pH in the reach from Link River Dam through the Keno Impoundment increases from spring to early summer and decreases in the fall; however, there are site-dependent variations in the observed trend. Peak values can exceed the ODEQ maximum of 9.0 (see Appendix C for additional details).

In the Hydroelectric Reach, pH is seasonally variable, with levels near neutral during the winter, increasing in the spring and summer. Peak values (8–9.2) have been recorded during the months of May and September with lower values documented June through August (7.5–8) (Raymond 2010), where the ODEQ pH maximum is 9 units (for the Klamath River upstream of the Oregon-California state line; Table 3.2-3) and the California pH maximum is 8.5 units (for the river downstream of state line; Table 3.2-4). Longitudinally, the lowest pH values were recorded downstream of J.C. Boyle Reservoir and the highest values in Copco and Iron Gate Reservoirs (Raymond 2008, 2009, 2010). High pH levels typically coincide with high algal photosynthesis rates at or near the water surface during periods of thermal stratification and high nutrient concentrations in the KHP reservoirs (Raymond 2008).

In the Lower Klamath Basin, seasonally high pH values continue to occur, with the highest pH values generally occur during late-summer and early-fall months (August–September). Daily cycles in pH also occur in this reach, with pH usually peaking during later afternoon or early evening, following the period of maximum photosynthesis (NCRWQCB 2010a). The California North Coast Basin Plan pH maximum of 8.5 units (Table 3.2-4) is regularly exceeded in the Klamath River downstream of Iron Gate Dam for the May–October 2005 dataset (see Appendix C for more detail). The most extreme pH exceedances typically occur just upstream of Shasta River; values generally decrease with distance downstream (FERC 2007; Karuk Tribe of California 2007, 2009, 2010). During the summer months, pH values also are elevated in the lower Klamath River from Weitchpec downstream to approximately Turwar Creek (see Appendix C for more detail).

In the Klamath Estuary, pH ranges between approximately 7.5 and 9, with peak values also occurring during the summer months (YTEP 2005). Daily variations in pH are typically on the order of 0.5 pH units, and fluctuations tend to be somewhat larger in the late summer and early fall. When large daily fluctuations are observed, they are likely caused by algal blooms that are transported into the estuary.

### 3.2.3.7 Chlorophyll-*a* and Algal Toxins

As primary producers, algae are critical components of riverine and lacustrine ecosystems. Their presence and abundance affect food web dynamics as well as physical water quality parameters (e.g., dissolved oxygen, pH, turbidity, and nutrients), the latter through rates of photosynthesis, respiration, and decay of dead algal cells (Horne and Goldman 1994). Cyanobacteria are also photosynthetic and can often be a nuisance aquatic species, occurring as large seasonal blooms that alter surrounding water quality. Some cyanobacteria species, such as *M. aeruginosa*, produce cyanotoxins (e.g., cyclic peptide toxins that act on the liver such as microcystin, alkaloid toxins such as anatoxin-a and saxitoxin that act on the nervous system) that can cause irritation, sickness, or in extreme cases, death to exposed organisms, including humans (World Health Organization [WHO] 1999).

Chlorophyll-*a*, a pigment produced by photosynthetic organisms including algae and cyanobacteria, is often used as a surrogate measure of algal biomass. Algae suspended in the water column (phytoplankton) can be represented as a concentration of chlorophyll-*a* (mg/L), while algae attached to bottom sediments or channel substrate (periphyton) can be represented as an areal biomass (mg chl-*a*/m<sup>2</sup>). Periphyton data are discussed in Section 3.4, Algae.

In the tributaries to Upper Klamath Lake, algae are generally present as periphyton (i.e., benthic or attached algae) species. Periphyton in these streams can cause water quality impairments for dissolved oxygen and pH (see Appendix C for more detail). In Upper Klamath Lake, algae are dominated by phytoplankton or suspended algae. Large summertime blooms of cyanobacteria are typically dominated by *Aphanizomenon flos-aquae*, with relatively smaller amounts of *M. aeruginosa* present. Despite this, *M. aeruginosa* is believed to be responsible for the production of microcystin in the lake, with concentrations in 2007-2008 equal to or greater than the World Health Organization (WHO) limit for drinking water (1 µg/L) and peaked at 17 µg/L, which is above the Oregon Department of Public Health guidelines for issuing public health advisories. Additional microcystin data collection in Upper Klamath Lake is ongoing, including measurement of toxin levels in native suckers (Vanderkooi et al. 2010, see Section 3.3, Aquatic Resources for more detail).

High (i.e., near 300 µg/L) summer chlorophyll-*a* concentrations in the Keno Impoundment (including Lake Ewauna) are due to large populations of algae, predominantly *A. flos-aquae*, entering the Klamath River from Upper Klamath Lake in summer (Kann 2006, Sullivan et al. 2008, et al. 2009, et al. 2010, FERC 2007). Such high concentrations do not persist farther downstream in J.C. Boyle Reservoir; however, in the two largest reservoirs (i.e., Copco 1 and Iron Gate) in the Hydroelectric Reach, chlorophyll-*a* concentrations increase again. Levels in Copco 1 and Iron Gate Reservoirs can be 2 to 10 times greater than those documented in the mainstem river, although they are not as high as those found in the Keno Impoundment (NCRWQCB 2010a) (see Appendix C for more detail). High levels of microcystin also occur during summer months in Copco 1 and Iron Gate Reservoirs; peak measured concentrations exceeded the California State Water Resources Control Board (SWRCB)/ Office of Environmental

Health and Hazard Assessment (OEHHA) public health threshold of 8 µg/L by over 1000 times in Copco 1 Reservoir during 2006–2009 and extremely high concentrations (1,000–73,000 µg/L) were measured during summer algal blooms in both Copco 1 and Iron Gate Reservoirs during 2009 (Watercourse Engineering 2011, see Appendix C for more detail).

Throughout the Klamath River, high chlorophyll-*a* concentrations have been shown to correlate with the toxigenic cyanobacteria blooms where *M. aeruginosa* was present in high concentrations and sharp increases in microcystin levels above WHO numeric targets (Kann and Corum 2009) and SWRCB, California Department of Public Health, and OEHHA guidelines (Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms [SWRCB 2010]). Since 2007, high levels of microcystin have prompted the posting of public health advisories around the reservoirs and along the length of the Klamath River during summer months. In 2010, the KHP reservoirs and the entire river downstream of Iron Gate Dam (including the estuary) were posted to protect public health due to elevated cyanobacteria cell counts and cyanotoxin concentrations.

Microcystin can also bioaccumulate in aquatic biota (Kann 2008, Kann et al. 2011); 85 percent of fish and mussel tissue samples collected during July through September 2007 in the Klamath River, including Iron Gate and Copco 1 Reservoirs, exhibited microcystin bioaccumulation (Kann 2008) (see Appendix C for more detail). Estuarine and marine nearshore effects (e.g., sea otter deaths) from cyanobacteria exposure have been reported in other California waters; however, none have been documented to date for the Klamath Estuary or marine nearshore (Miller et al. 2010). Section 3.3.3.2, Physical Habitat Descriptions - Water Quality - Algal Toxins presents a discussion of algal toxins as related to fish health.

### **3.2.3.8 Inorganic and Organic Contaminants**

In general, information regarding contaminants in the Upper Klamath Basin upstream of the Hydroelectric Reach is unavailable. Human activities such as illegal dumping may be a source of inorganic and organic contaminants to the lower Sprague and Williamson river sub-basins (Rabe and Calonje 2009). The exception to this is arsenic; natural geologic sources of arsenic may be causing relatively high levels of this chemical element in the Upper Klamath Basin, as is the case in other south central and southeastern Oregon basins (Sturdevant 2010).

#### **3.2.3.8.1 Water Column Contaminants**

Existing water quality data are available from the California Surface Water Ambient Monitoring Program (SWAMP). SWAMP data from 2001 through 2005 indicate that at eight monitoring sites from the California-Oregon state line (RM 208.5) to Klamath River at Klamath Glen (RM 5.8) the majority of inorganic constituents (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), were in compliance with water quality objectives. Aluminum concentrations in some samples may have been slightly elevated above USEPA freshwater aquatic life and secondary standards for drinking water, where a greater sampling frequency would be required to

determine actual exceedances. Grab samples were analyzed for 100 pesticides, pesticide constituents, isomers, or metabolites; 50 polychlorinated biphenyls (PCBs) congeners; and 6 phenolic compounds. Results indicated no PCBs and only occasional detections of pesticides (NCRWQCB 2008) (see Appendix C for more detail).

#### **3.2.3.8.2 Sediment Contaminants**

To investigate the potential for toxicity of the sediments trapped in the reservoirs of the Four Facilities, Shannon & Wilson, Inc. (2006) collected sediment samples from J.C. Boyle, Copco 1, and Iron Gate Reservoirs during 2004–2005 and analyzed them for contaminants including acid volatile sulfides, metals, pesticides, chlorinated acid herbicides, PCBs, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), cyanide, and dioxins. No herbicides or PCBs were found above screening levels and only one sample exceeded applicable screening levels for VOCs ethyl benzenes and total xylenes (Shannon & Wilson, Inc. 2006). While cyanide was detected in multiple sediment cores, it was not found in the bioavailable toxic free cyanide form (HCN or CN<sup>-</sup>).

Dioxin, a known carcinogen, was also measured in the Shannon & Wilson (2006) study. Long-term exposure to dioxin in humans is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions. In the 2004–2005 reservoir samples, measured levels were 2.48–4.83 pg/g (picograms per gram or parts per trillion [ppt] expressed as Toxic Equivalent Concentrations) and did not exceed applicable screening levels for human health and ecological receptors (Shannon & Wilson, Inc. 2006, Dillon 2008, USEPA 2010b) or estimated background dioxin concentrations (2–5 ppt) for non-source-impacted sediments throughout the U.S. and specifically in the western U.S. (USEPA 2010b) (see Appendix C for more detail). The measured levels did exceed Oregon human health and bioaccumulation thresholds; however, Oregon’s human health thresholds include risk-based values for subsistence fishers as well as the general consuming public and are quite a bit lower (0.0011–1.1 pg/g dry weight (DW) Toxicity equivalency quotient [TEQ]) than many other screening levels (ODEQ 2007) (see Appendix C for more detail).

As part of the Klamath Dam Removal Secretarial Determination studies, a sediment evaluation was undertaken during 2009–2011 to evaluate potential environmental and human health impacts of the downstream release of sediment deposits currently stored behind the dams under the Proposed Action<sup>1</sup>. Sediment cores were collected during 2009–2010 at multiple sites and at various sediment depths per site in J.C. Boyle Reservoir, Copco 1 Reservoir, Iron Gate Reservoir, and the Klamath Estuary (Department of the Interior [DOI] 2010). A total of 501 analytes were quantified in the sediment samples, including metals, poly-aromatic hydrocarbons (PAHs), PCBs, pesticides/herbicides, phthalates, VOCs, SVOCs, dioxins, furans, and polybrominated diphenyl ethers (PBDEs) (i.e., flame retardants). Samples were analyzed for sediment

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<sup>1</sup> Estimates of the volume of sediment deposits stored within J.C. Boyle, Copco 1 and 2, and Iron Gate Reservoirs include 10.0 million m<sup>3</sup> (13.1 million yd<sup>3</sup>) (Greimann et al. 2010), 11.1 million m<sup>3</sup> (Eilers and Gubala 2003), and 15.6 million m<sup>3</sup> (GEC 2006) (14.5 to 20.4 million yd<sup>3</sup>). See also Section 3.11 of this Klamath Facilities Removal EIS/EIR.

chemistry and elutriate (pore water) chemistry, and bioassays were conducted on the sediment and elutriate using fish and invertebrate national benchmark toxicity species (see below for discussion of the bioaccumulation component of this study). Five exposure scenarios were evaluated, which generally correspond to potential effects evaluated in this Klamath Facilities Removal EIS/EIR. Based on comparisons of sediment chemistry to screening levels (SLs) and the results of bioassays (see Section C.7.1.1. for more detail), the reservoir sediments do not appear to be highly contaminated. No consistent pattern of elevated chemical composition was observed across discrete sampling locations within a reservoir and no single reservoir was observed to be consistently more or less contaminated. Where elevated concentrations of chemicals in sediment were found, the degree of exceedance based on comparisons of measured detected chemical concentrations to SLs was small and in several cases (i.e., arsenic, mercury, 2,3,7,8-TCDD, total PCBs) may reflect regional background conditions (CDM 2011; see Section C.7.1.1 for more detail).

Toxicity tests generally indicated low potential for sediment toxicity to benchmark benthic indicator species; the exception to this occurred in a single sample from J.C. Boyle Reservoir, where survival of the benthic amphipod *Hyalella azteca* indicated a moderate potential for sediment toxicity (CDM 2011). TEQs for dioxin, furan, and dioxin-like PCBs in reservoir and estuary sediment samples were within the range of local background values and suggest a limited potential for adverse effects for fish exposed to reservoir sediments (CDM 2011). Lastly, sediment samples were also evaluated for levels of known bioaccumulative compounds; ODEQ bioaccumulation sediment screening level values (SLVs) were not exceeded in J.C. Boyle Reservoir sediments, with the exception of a small number of samples for dichlorodiphenyltrichloroethane (DDT)s (see Section C.7.1.1 for more detail).

#### **3.2.3.8.3 Contaminants in Aquatic Biota**

Assessments of contaminants in fish tissue for the Hydroelectric Reach have been undertaken by SWAMP and PacifiCorp. SWAMP data include sport fish tissue samples collected during 2007 and 2008 to evaluate accumulated contaminants in nearly 300 lakes statewide. Sport fish were sampled to provide information on potential human exposure to selected contaminants and to represent the higher aquatic trophic levels (i.e., the top of the aquatic food web).

In the Hydroelectric Reach, fish tissue samples were collected in Copco 1 and Iron Gate Reservoirs and analyzed for total mercury, selenium, and PCBs (Iron Gate Reservoir only) (Davis et al. 2010). SWAMP data for Iron Gate and Copco reservoirs indicate mercury tissue concentrations above the USEPA criterion of 300 ng/g methylmercury (for consumers of noncommercial freshwater fish); and greater than OEHHA public health guideline levels advisory tissue levels (Klasing and Brodberg 2008) for consumption for 3 and 2 servings per week (70 and 150 ng/g wet weight, respectively) and the fish contaminant goal (220 ng/g wet weight). Measured selenium concentrations were 3–4 orders of magnitude lower than OEHHA thresholds of concern (2,500–15,000 ng/g wet weight) and PCB concentrations were below the lowest OEHHA threshold (i.e., fish contaminant goal of 3.6 ng/g wet weight) (Davis et al. 2010).



In a screening-level study of potential chemical contaminants in fish tissue in Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, and in Upper Klamath Lake, PacifiCorp analyzed metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc), organochlorine (pesticide) compounds, and PCBs in largemouth bass (*Micropterus salmoides*) and black bullhead catfish (*Ameiurus melas*) (PacifiCorp 2004c). PacifiCorp reported that, in general, contaminant levels in fish tissue were below screening level values for protection of human health (USEPA 2000) and recommended guidance values for the protection of wildlife (MacDonald 1994). Exceptions to this include some tissue samples for total mercury, arsenic, total DDTs and total PCBs, when compared to screening levels for wildlife and subsistence fishers (individual comparisons are shown in Appendix C for more detail). Dioxins were not tested.

To supplement existing fish tissue data and provide additional lines of evidence in the Secretarial Determination sediment evaluation (see above and Section C.7.1.1), the potential for chemicals in sediment and elutriate samples to bioaccumulate in aquatic species at concentrations above screening levels for ecological receptors (i.e., fish, birds, humans/mammals) was investigated. Bioaccumulation studies were conducted using laboratory invertebrates exposed to reservoir-derived sediments and two species of field-caught fish collected during late September 2010 from J.C. Boyle, Copco 1, and Iron Gate reservoirs (CDM 2011, see Section C.7.1.1 for more detail). Results indicate that multiple chemicals were found in invertebrate (acenaphthene, arsenic, benzo(a)pyrene, DDD/DDE, endosulfan I, endosulfan II, endosulfan sulfate, fluoranthene, hexachlorobenzene, lead, mercury, phenanthrene, pyrene, total PBDEs, total PCBs) and fish (i.e., 2,3,7,8-TCDD, arsenic, DDE/DDT, dieldrin, endrin, mercury, mirex, selenium, and total PCBs) tissue under current conditions (CDM 2011). Mercury exceeded tissue-based toxicity reference values (TRVs) for perch in Iron Gate Reservoir and bullhead samples in all three reservoirs (CDM 2011). TRVs are not available for several chemicals detected in invertebrate and fish tissue (CDM 2011, see Section C.7.1.1 for more detail).

### **3.2.4 Environmental Consequences**

#### **3.2.4.1 Environmental Effects Determination Methods**

The Klamath Facilities Removal EIS/EIR water quality analysis includes consideration of the effects of the Proposed Action and alternatives on water temperature, suspended sediments, nutrients (TN, TP, nitrate, ammonium, ortho-phosphorus), dissolved oxygen, pH and alkalinity, chlorophyll-*a* and algal toxins, and inorganic and organic contaminants in water and reservoir sediments. For all water quality parameters, the analysis approach for water quality effects associated with facilities removal under Klamath Hydroelectric Settlement Agreement (KHSa) is conducted at the project-level and is presented by water quality parameter. Elements of Klamath Basin Restoration Agreement (KBRA) restoration projects that would affect water quality are identified and analyzed at a program-level.

For water quality, existing conditions is generally defined as physical, chemical, and biological characteristics of water in the area of analysis at the time of the Notice of Preparation (Water Year [WY] 2010). However, while some water quality parameters to be analyzed here are well-represented by data collected during WY2010, most are represented by data collected within the past 5 to 10 years (WY2000–WY2010). Further, the start of the analysis period for the hydrology, water temperature, and suspended sediment modeling conducted as part of Secretarial Determination studies corresponds to WY2012, or just following the expected date for the Secretarial Determination regarding dam removal. Despite several existing regulations or agreements that may be partially implemented between WY2010 and WY2012 and that would affect water quality, in general, conditions in the Klamath River are not expected to be substantially different in WY2012 than conditions during WY2000–WY2010. Therefore, for the water quality analysis existing conditions generally encompass the 10 to 12-year period prior to WY2012 (summarized in Section 3.2.3; additional detail provided in Appendix C).

The KHSA presents nine water-quality-related Interim Measures (IMs) (KHSA Section 1.2.4):

- IM 3, Iron Gate Turbine Venting
- IM 5, Iron Gate Flow Variability
- IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement
- IM 8, J.C. Boyle Bypass Barrier Removal
- IM 11, Interim Water Quality Improvements
- IM 13, Flow Releases and Ramp Rates
- IM 16, Water Diversions

As discussed in Chapter 2, IM 3 is already complete and included in existing conditions. IMs 5, 7, 8, and 13 are part of the No Action/No Project Alternative because they would be implemented as part of PacifiCorp's Habitat Conservation Plan<sup>2</sup>. IM 5, Iron Gate Flow Variability, would alter flow variability, but the flows would stay within the historic range of operations. One year of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement is included in the No Action/No Project Alternative because work is scheduled to begin in Fall 2011 before the Secretary makes a determination. IM 8, J.C. Boyle Barrier Removal, could have construction-related water quality effects. IM 13, Flow Releases and Ramp Rates stipulates no change in the current flows from J.C. Boyle, so no water quality effects are anticipated as part of existing conditions.

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<sup>2</sup> DOI has incorporated by reference pertinent information in this chapter from: NOAA Fisheries 2011. Draft Environmental Assessment for Authorization for Incidental Take and Implementation of the PacifiCorp Klamath Hydroelectric Project Interim Operations Habitat Conservation Plan for Coho Salmon Available at: <http://klamathrestoration.gov/>. DOI encourages readers to review this source document for more detailed information than is summarized in this EIS/R. Though not final this environmental analysis in NOAA Fisheries 2011 found no significant impact from IM implementation on Water Resources (Climate and Water Flow and Water Quality) or Biological Resources.

Remaining IMs are included in Alternatives 2 and 3. Seven years of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could affect water quality. Planning efforts under IM 11, Interim Water Quality Improvements are ongoing; however, pilot scale projects are still in the data collection or planning stage, so an assessment of water quality impacts is not yet practical. IM 16, the elimination of three screened diversions on Shovel and Negro Creeks and relocation of the points of diversion from the creeks to the Klamath River, could have construction-related water quality effects. Additionally, IM 15, Water Quality Monitoring, has produced some monitoring results (Watercourse Engineering, Inc. 2011) that are incorporated into the existing conditions summary.

Within the period of analysis (i.e., 50 years) reasonably foreseeable actions associated with water quality are anticipated to be the following:

- Ongoing restoration activities in the Klamath Basin (see Section 2.4.2).
- Implementation of TMDLs for Oregon and California (see Section 3.2.2.4)
- National Oceanic and Atmospheric Administration (NOAA) Fisheries Service 2010 Biological Opinion mandatory flows (see Section 2.3.1).
- California Department of Fish and Game (CDFG) Code Section 5937 instream flow mandate for tributaries to the mainstem Klamath River<sup>3</sup>
- Climate change (see Section 3.10.3.1).

Therefore, under the No Action/No Project Alternative, elements of ongoing restoration projects, TMDLs, and programs mandating stream flows that would affect future water quality are identified for a specific reach and/or water quality parameter and included as part of the analysis narrative in a qualitative or, if possible, a quantitative manner.

Under the Proposed Action and remaining alternatives, the analysis of water quality effects considers both short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities)<sup>4</sup>. While the timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects, some short-term effects are anticipated and, for water quality, would be heavily influenced by the release of fine sediment deposits currently stored behind the dams to the downstream river reaches, the estuary, and the marine nearshore environment. This is because mobilization of reservoir sediment deposits would be most intense during the first year or two following dam removal, when the majority of sediments would be eroded by river flows (Greimann et al. 2011, Stillwater Sciences 2008). Short-term effects would also occur as a result of construction activities related to fish passage structures and restoration activities associated with dam removal and KBRA implementation. Under the Proposed Action and other dam removal alternatives, long-term effects on water quality would be

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<sup>3</sup> This action is not included in the project description (Section 2) since it will occur only in tributaries to the middle and lower Klamath River. It may increase flows to the mainstem Klamath River, thus it is briefly discussed as part of the No Action/No Project Alternative analysis for water quality.

<sup>4</sup> Note that for the purposes of this analysis the use of “short-term” as <2 years is not the same as the use of “short-term (acute)” when applied to numeric water quality criteria for determining thresholds of aquatic life toxicity (i.e., 24-hr or 96-hr exposure periods).

primarily characterized by the shift from lacustrine to riverine environments in the Hydroelectric Reach and the concomitant changes in physical and chemical processes on water quality in this reach and downstream river reaches. Parameter-specific analysis methods are discussed below.

#### **3.2.4.1.1 Water Temperature**

Short-term (<2 years following dam removal/construction of fish passage facilities) effects of the alternatives on water temperature are assessed based on the existing conditions understanding of the seasonal effects of the KHP reservoirs on water temperature within the Hydroelectric Reach and downstream of the dam.

For long-term (2–50 years following dam removal/construction of fish passage facilities) effects of the alternatives, quantitative Klamath River water quality model (KRWQM) results for “current conditions” and dams-out conditions are available (PacifiCorp 2004a, Dunsmoor and Huntington 2006, FERC 2007; see Appendix D for more detail), but they do not include implementation of the Oregon and California TMDLs, which are considered as reasonably foreseeable actions under the No Action/No Project Alternative (see above list). The Klamath TMDL model includes a dams-in scenario (T4BSRN) assuming full attainment of the Oregon and California TMDLs with all Four Facilities in place (Tetra Tech 2009), similar to the conditions for the No Action/No Project Alternative. The Klamath TMDL model T1BSR natural conditions scenario is also useful for analyzing water temperature, since this parameter relies upon a comparison to background or natural levels for regulatory water quality compliance. The Klamath TMDL TOD2RN and TCD2RN scenarios assume the removal of the Four Facilities and full TMDL implementation (Tetra Tech 2009), which is similar to the Proposed Action; to place the Proposed Action analysis in the proper context, these scenarios are generally considered with respect to starting assumptions (i.e., model boundary conditions) about water temperature. These scenarios also represent Keno Dam as the historical natural Keno Reef, such that the Keno Reach is not a free-flowing reach (Tetra Tech 2009).

Since the TMDL model scenarios do not include climate change projections or changes in future hydrology included under KBRA, one additional set of water temperature modeling results is used for the Klamath Facilities Removal EIS/EIR analysis; the RBM10 model was developed as part of the Secretarial Determination studies and includes the effects of climate change and KBRA hydrology on future water temperatures. RBM10 model results use climate change predictions from five Global Circulation Models (GCMs) (see Appendix D for more detail).

Appendix D, Table D-1 shows the reaches where KRWQM, Klamath TMDL, and RBM10 model results are used for the water quality analysis under each alternative. Since no one existing model captures all of the elements analyzed for water temperature in this Klamath Facilities Removal EIS/EIR, where possible, model outputs are used in combination to assess similar spatial and temporal trends in predicted water temperature.

#### **3.2.4.1.2 Suspended Sediments**

The Proposed Action was optimally developed as an alternative, to allow reservoir drawdown to occur during winter months when precipitation, river flows, and turbidity are naturally highest. Results from the sediment mobility analysis conducted by the DOI are used to provide estimates of short-term (<2 years following dam removal) suspended sediment concentrations (SSCs) downstream of Iron Gate Dam under the Proposed Action and other dam removal alternatives. The sediment mobility analysis used existing suspended sediment data collected by the U. S. Geological Survey (USGS) at the Shasta River near Yreka (USGS gage no. 11517500), Klamath River near Orleans (USGS gage no. 11523000), and Klamath River near Klamath (USGS gage no. 11530500) gages to estimate daily total SSCs (mg/L) as a function of flow (cfs) using the SRH-1D sediment transport model (Sedimentation and River Hydraulics–One Dimension Version 2.4) (Huang and Greimann 2010, Greimann et al. 2011). Daily total SSCs were modeled for existing conditions representing WY 1961–2008 (“background”) and for conditions following dam removal (WY 2020–2021). SRH-1D model output representing total sediments, including both inorganic (i.e., mineral) and organic (i.e., algal-derived) sediments, is applied to the Klamath Facilities Removal EIS/EIR suspended sediment analysis. The SRH-1D model assumes a three-phase drawdown for Copco 1 Reservoir beginning on November 1, 2019, and a single-phase drawdown for J.C. Boyle and Iron Gate Reservoirs beginning on January 1, 2020 consistent with the Proposed Action. This would allow maximum SSCs to occur during winter months when flows are naturally high in the mainstem river (Stillwater Sciences 2008, Greimann et al. 2011). The analysis of short-term (<2 years following dam removal) effects also considers results from previous studies (e.g., Stillwater Sciences 2010) regarding anticipated sediment release from Klamath River Dam removal within the context of basin sediment delivery.

To inform long-term (2–50 years following dam removal/construction of fish passage facilities) effects determinations on suspended materials under all of the alternatives, existing data sources for TSS and turbidity sources to the Hydroelectric Reach and the lower Klamath River (e.g., PacifiCorp 2004a, 2004b; YTEP 2005) are used. Existing analyses of the potential effects of dam removal on long-term sediment supply (Stillwater Sciences 2010) are also considered.

#### **3.2.4.1.3 Nutrients**

Under the Proposed Action, short-term (<2 years following dam removal) nutrient loads associated with high SSCs are assessed in a qualitative manner, considering the likelihood of sediment deposition in the lower river, seasonal rates of primary productivity and microbially mediated nutrient cycling, and potential light limitation of primary producers given the high sediment concentrations in the river.

To determine general long-term spatial and temporal trends of nutrients in the Hydroelectric Reach and the lower Klamath River under all of the alternatives, the T4BSRN, TOD2RN and TCD2RN Klamath TMDL scenarios (Tetra Tech 2009) are presented. To place the Proposed Action analysis in the proper context, the TOD2RN and TCD2RN scenarios are generally considered with respect to starting assumptions (i.e., model boundary conditions) about nutrient concentrations. Reaches where

T4BSRN, TOD2RN and TCD2RN information is available include all reaches associated with the EIS/EIR nutrient analysis from J.C. Boyle Reservoir to the Klamath Estuary (see Appendix D, Table D-1).

Additionally, an existing analysis regarding potential nutrient dynamics under a “dams-out” scenario (i.e., Asarian et al. 2010) is used to inform the assessment of the long-term effects of the Proposed Action on nutrients. Using nutrient measurements and hydrologic data for the Klamath River, Asarian et al. (2010) constructed mass-balance nutrient budgets to evaluate nutrient dynamics in free-flowing reaches of the Klamath River, including longitudinal trends in absolute and relative retention of phosphorus and nitrogen. The analysis also compared nutrient retention rates between free-flowing river reaches and reservoir reaches and developed a range of estimates for how seasonal TP and TN concentrations downstream of Iron Gate Dam might be altered by dam removal. The analysis used hydrologic and nutrient data collected by a variety of tribal, federal, and state agencies, and PacifiCorp, during June-October of 2005–2008. The mass balance estimates for 2005–2008 improve upon estimates for the period 1998–2002 (Asarian and Kann 2006b) by using flow- and season-based multiple regression models for predicting daily nutrient concentrations and loads and quantification of uncertainty, relatively lower laboratory reporting limits, higher sampling frequency, and nutrient speciation (i.e., not just TN and TP). The effects of dam removal were quantified using calculated relative retention rates in river reaches and comparing them to results from a retention study of Copco 1 and Iron Gate Reservoirs by Asarian et al. (2009).

#### **3.2.4.1.4 Dissolved Oxygen**

Both short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2-50 years following dam removal/construction of fish passage facilities) dissolved oxygen effects due to the alternatives are analyzed. For short-term effects under the Proposed Action and dam removal alternatives, results of numerical modeling conducted by the Lead Agencies as part of the Klamath Dam Removal Secretarial Determination studies are used to describe predicted short-term dissolved oxygen levels in the Hydroelectric Reach and downstream of Iron Gate Dam due to mobilization of fine sediments following dam removal. In the 1-dimensional, steady-state model, the different short-term oxygen demand terms (i.e., BOD, immediate oxygen demand [IOD], and sediment oxygen demand [SOD]) are off-set by tributary dilution and re-aeration using an approach similar in concept to Streeter and Phelps (1925) dissolved oxygen-sag. This BOD/IOD spreadsheet model also includes chemical oxygen demand generated from the conversion of ammonium and other nitrogenous compounds in reservoir sediments to nitrate under oxic conditions. This is termed nitrogenous oxygen demand and is inherently included in the oxygen demand rate constants used in the BOD/IOD spreadsheet model (Stillwater Sciences 2011).

IOD and BOD are predicted in the spreadsheet model using empirically derived oxygen depletion rates for a particular SSC based on laboratory incubations conducted under the Secretarial Determination oxygen demand study (Stillwater Sciences 2011). Oxygen depletion rates are scaled to the level of suspended sediments expected under each of the three water year types considered for the DOI hydrology and sediment transport

modeling assessment (i.e., typical dry, median, and typical wet water years) (see Section 3.2.4.1).

The BOD/IOD spreadsheet model assumes a three-phase drawdown for Copco 1 Reservoir beginning on November 1, 2019, and a single-phase drawdown for J.C. Boyle and Iron Gate Reservoirs beginning on January 1, 2020 consistent with the Proposed Action (Greimann et al. 2011). This would allow maximum SSCs to occur during winter months when flows are naturally high in the mainstem river (Stillwater Sciences 2008, Greimann et al. 2011). While the KHP reservoirs exhibit varying degrees of thermal stratification and hypolimnetic anoxia during summer months (see Section 3.2.3.1), all of the reservoirs tend to experience fully-mixed conditions by November/December and remain mixed through April/May. Thus, drawdown beginning in December is expected to involve a well-oxygenated water column and, potentially, an oxic surficial sediment layer. This is important because the spreadsheet model is highly sensitive to background concentrations of dissolved oxygen (Stillwater Sciences 2011), which are generally highest in the KHP reservoirs during winter months (see Section 3.2.3.1). The BOD/IOD spreadsheet model results encompass a 6-month period following drawdown in order to estimate potential dissolved oxygen minimums corresponding to the period of greatest sediment transport in the river under the Proposed Action.

For long-term (2–50 years following dam removal/construction of fish passage facilities) effects, existing information on water quality dynamics and physical, chemical, and biological drivers for dissolved oxygen in the river are used to inform the effects determination for all of the alternatives. Dissolved oxygen model results from PacifiCorp relicensing efforts (FERC 2007) and the California Klamath River TMDL (NCRWQCB 2010a; see Section 3.2.2.7.4) are also used for the long-term effects analysis. Where possible, the Klamath TMDL model output is used in combination with KRWQM output to assess similar spatial and temporal trends in predicted dissolved oxygen. To place the Proposed Action analysis in the proper context, the TOD2RN and TCD2RN model predictions (Tetra Tech 2009) are considered with respect to starting assumptions (i.e., model boundary conditions) about dissolved oxygen (and nutrient) concentrations. Reaches where T4BSRN, TOD2RN and TCD2RN information is available include all reaches associated with the EIS/EIR dissolved oxygen analysis from J.C. Boyle Reservoir to the Klamath Estuary (see Appendix D, Table D-1).

#### **3.2.4.1.5 pH**

Short-term (<2 years following dam removal/construction of fish passage facilities) effects of the alternatives on pH are assessed based on the existing conditions understanding of the seasonal effects of the KHP reservoirs on pH within the Hydroelectric Reach and downstream of the dam.

For long-term (2–50 years following dam removal/construction of fish passage facilities) effects, existing data on pH in the Hydroelectric Reach and the Lower Klamath Basin are used to inform the effects determination for the Proposed Action. As for water temperature, nutrients, and dissolved oxygen, T4BSRN, TOD2RN and TCD2RN Klamath TMDL scenarios (Tetra Tech 2009) are available for pH. Reaches where

T4BSRN, TOD2RN and TCD2RN information is available include all reaches associated with the EIS/EIR pH analysis from J.C. Boyle Reservoir to the Klamath Estuary (see Appendix D, Table D-1).

#### **3.2.4.1.6 Chlorophyll-*a* and Algal Toxins**

Effects of the alternatives on the algal community (phytoplankton, aquatic macrophytes, riverine phytoplankton and periphyton) in the Klamath River are discussed in Section 3.4, Algae. Chlorophyll-*a* is analyzed as a separate water quality parameter in the Klamath Facilities Removal EIS/EIR because it is a surrogate measure of algal biomass and it is included as a numeric criterion associated with the Oregon nuisance algae growth water quality objective (see Table 3.2-3) and a target specific to the KHP reservoirs in the California Klamath River TMDLs (NCRWQCB 2010a). The Hoopa Valley Tribe water quality objective for chlorophyll-*a* is a measure of attached (benthic) algal growth (see Table 3.2-6) and is discussed further in Section 3.4, Algae.

Quantitative predictive tools for chlorophyll-*a* are not available for the alternatives. While the California Klamath TMDLs model includes a chlorophyll-*a* component, covering both periphyton and phytoplankton, the model appears to over predict chlorophyll-*a* under the “dams out” scenario (Tetra Tech 2008) and is therefore not used for the Klamath Facilities Removal EIS/EIR analysis. The chlorophyll-*a* target (10 ug/L) developed for the KHP reservoirs in the California Klamath TMDLs is based on a Nutrient Numeric Endpoints analysis, which appears to be a conservative estimate of mean summer chlorophyll-*a* concentrations required to move the system toward support of beneficial uses (Creager et al. 2006, Tetra Tech 2008).

The chlorophyll-*a* effects determinations are based on a qualitative assessment of whether the alternatives would result in exceedances of the Oregon 15 ug/L water quality objective or the California 10 ug/L target for the KHP reservoirs and adversely affect beneficial uses with respect to water column concentrations of chlorophyll-*a*. Growth conditions for suspended algae (i.e., nutrient availability, impounded water) are considered as part of the qualitative analysis, where predicted increases in nutrient availability, water temperatures, and the availability of lacustrine (lake or reservoir) conditions would correspondingly increase chlorophyll-*a* concentrations.

Since algal toxins are a water quality concern and have the potential to affect designated beneficial uses of water, an analysis of project effects on algal toxins as related to water quality standards and beneficial uses is included in the water quality effects determinations. There are no quantitative models predicting algal toxin trends under a dam removal scenario, thus the effects determinations are based upon trends in the density of *M. aeruginosa* (or other toxin-producing blue-green algae) to algal toxin concentrations (see Section 3.2.3.7) discerned from data collected in the Hydroelectric Reach and the Lower Klamath Basin. This information is considered along with the potential for changes in habitat availability for *M. aeruginosa* (or other toxin-producing blue-green algae) under the alternatives.



#### **3.2.4.1.7 Inorganic and Organic Contaminants**

The determination of potential toxicity and bioaccumulation with respect to aquatic species and humans under the alternatives is based on the evaluation of existing data on inorganic and organic contaminants associated with both reservoir water quality and sediment deposits, as well as new sediment contaminant data collected as part of the ongoing Secretarial Determination studies.

The Secretarial Determination sediment evaluation process has followed screening protocols of the Sediment Evaluation Framework (SEF) for the Pacific Northwest, issued in 2009 by the interagency Regional Sediment Evaluation Team (RSET). The SEF is a regional guidance document that provides a framework for the assessment and characterization of freshwater and marine sediments in Idaho, Oregon, and Washington (RSET 2009). The SEF involves a data screening assessment to compare reservoir sediment data to available and appropriate sediment maximum levels, screening levels, and bioaccumulation triggers. It also provides guidance for conducting elutriate chemistry, toxicity bioassays, and bioaccumulation tests, and special evaluations such as and risk assessments (the latter not utilized for this evaluation). The results of the SEF-based evaluation for the 2009–2010 Klamath River sediment samples are used primarily to inform the water quality effects determinations related to inorganic and organic contaminants under the Proposed Action.

To systematically consider potential impact pathways for each of the alternatives for the Secretarial Determination process, sediment data were compared to established sediment screening values in a step-wise manner. Elutriate (sediment pore water) data were also evaluated through comparison with a suite of regional, state and federal standards for water quality; the comparison is first carried out without consideration of dilution as a conservative approach (CDM 2011).

Biological testing was also conducted, using the SEF approach, and consisted of sediment and elutriate toxicity testing and tissue analyses, or other special evaluations designed to provide more empirical evidence regarding the potential for sediment contaminant loads to have adverse effects on receptors (RSET 2009). While whole sediment toxicity tests identify potential contamination that may affect bottom-dwelling (benthic) organisms, toxicity tests using suspension/elutriates of dredged material assess potential water column toxicity. Bioaccumulation evaluation is undertaken when bioaccumulative chemicals of concern exceed or may exceed sediment screening levels, and thus further evaluation is needed to determine whether they pose a potential risk to human health or ecological health in the aquatic environment (RSET 2009).

Results from elutriate and sediment toxicity bioassays and sediment bioaccumulation tests carried out for the Secretarial Determination studies are used to provide additional information beyond simple comparisons of sediment contaminant levels to individual-contaminant regional or national screening levels. The results of sediment and elutriate toxicity bioassays provide a direct assessment of potential toxicity that takes into account possible interactive effects of mixtures of multiple contaminants, and of potential contaminants that may be present but were not individually measured.

#### **3.2.4.2 Significance Criteria**

Significance criteria to be used for the determination of impacts on beneficial uses of water and water quality are listed below. These criteria are excerpted from the list of ten significance criteria generally applicable to hydrology and water quality environmental factors for proposed projects in California (Appendix E in California Resources Agency [2010]). The criteria also encompass elements of Oregon and California water quality standards.

Effects on beneficial uses of water and water quality will be considered significant if the Proposed Action or alternatives would do any of the following:

- Result in regular exceedances of water quality standards or waste discharge requirements.
- Result in substantial adverse effects on beneficial uses of water.

For the purposes of this EIS/EIR, substantial is defined as “of considerable importance to water quality and the support of beneficial uses”. “Substantial adverse effects” are intended to correspond to water quality parameters that are included on the CWA Section 303(d) list (see Table 3.2-8) because if a parameter is listed, it has already been determined that beneficial uses are not supported due to regular exceedances of established numeric standards or water quality objectives. Substantial adverse effects can also apply to water quality parameters that would experience degradation within the EIS/EIR short-term time from of less than two years.

Additional criteria related to groundwater and hydrology (i.e., drainage, runoff, stormwater, flooding, and inundation) will be addressed in Section 3.6, Flood Hydrology or Section 3.7, Groundwater.

##### **3.2.4.2.1 Thresholds of Significance for Numeric Standards or Water Quality Objectives**

Thresholds of significance for established numeric standards and water quality objectives are the numeric values themselves. The numeric values for Oregon, California, Hoopa Valley Tribe, and the Ocean Plan are presented in Tables 3.2-3 through 3.2-7.

Numeric values presented in Tables 3.2-3 through 3.2-7 are used as thresholds of significance for water temperature, dissolved oxygen, and pH. Other numeric values presented in Tables 3.2-3 through 3.2-7, including Oregon and California turbidity standards, California nitrate and nitrite standards for the support of municipal beneficial uses, the Hoopa Valley Tribe criterion for chlorophyll-*a* as periphyton, and the Hoopa Valley Tribe ammonia and nitrate standards for the support of cold freshwater habitat and municipal beneficial uses, are not used as thresholds of significance. The reasons for not using these numeric standards in the water quality effects determinations are discussed below, by parameter.

**3.2.4.2.2 Thresholds of Significance for Narrative Standards or Water Quality Objectives**

**3.2.4.2.2.1 Suspended Sediments**

Oregon has a numeric turbidity standard based upon increases relative to background levels (see Table 3.2-3), and California's water quality objective for turbidity is based upon increases relative to natural conditions (see Table 3.2-4). Turbidity levels under natural conditions are not readily available in the Klamath River data record. While a relationship between turbidity and suspended sediment can be developed on a watershed-specific basis, seasonal coincident suspended sediment and turbidity data for the Klamath Basin are not currently sufficient, either temporally or spatially, to develop a robust relationship between these two parameters for either background levels or natural conditions levels (Stillwater Sciences 2009). For these reasons, the established numeric water quality objectives for turbidity in Oregon and California are not used for the water quality effects determination; instead, the narrative sediment water quality objectives are applied to the analysis.

California's North Coast Basin Plan water quality objectives for suspended material, settleable material, and sediment are narrative and require that waters do not contain concentrations that cause nuisance or adversely affect beneficial uses (see Table 3.2-4). While the Klamath River has multiple designated beneficial uses (see Table 3.2-2), the use most sensitive to water quality is the cold freshwater habitat (COLD) associated with salmonids (NCRWQCB 2010a). In order to adequately protect this use from *short-term* (<2 years following dam removal) effects of the Proposed Action, the water quality effects determination methods focus on the suspended material water quality objective and rely upon the extensive sediment transport modeling effort undertaken for the Secretarial Determination process to quantify predicted SSCs for 1 to 2 years following dam removal (see Section 3.2.4.1). An alternative "dose-response" approach to developing a numeric suspended sediments threshold of significance for potential short-term effects has been adopted, as detailed in Appendix D, Section D.2. Based on this approach, the water quality effects determination uses a predicted suspended sediment value of 30 mg/L over a 4-week exposure period as a general threshold of significance for analyzing the *short-term* effects of the alternatives.

A more detailed analysis of suspended sediment effects on key fish species, including consideration of specific life history stages, SSCs, and exposure period, is required for a comprehensive assessment of the impacts of the alternatives on the cold water designated beneficial use. This level of analysis is presented in Section 3.3, Aquatic Resources and appendices to this section. Further discussion of particular effects of suspended sediment on shellfish and estuarine and marine organisms is also presented in Section 3.3.4.3, Aquatic Resources.

**3.2.4.2.2.2 Nutrients**

Oregon does not stipulate numeric nutrient water quality standards (see Table 3.2-3). California has a narrative water quality objective for biostimulatory substances and does not stipulate numeric nutrient water quality standards for the cold water habitat beneficial use (see Table 3.2-4). California does have numeric nitrate and nitrite standards for the

support of municipal beneficial uses (i.e., drinking water). However, these standards are much higher than concentrations that have been measured in the Klamath Basin, such that there is no indication that the municipal beneficial use is not being met. Hoopa Valley Tribe also has a nitrate standard for municipal beneficial uses, which is similarly high.

The California Klamath River TMDLs provide the numeric interpretation of the narrative biostimulatory substances objective for the Klamath River through numeric targets for nutrients, organic matter, chlorophyll-*a*, *M. aeruginosa* and microcystin. The numeric TMDL targets for nutrients (TP and TN) and organic matter (as carbonaceous biochemical oxygen demand [CBOD]) are established for the tailraces of Copco 2 and Iron Gate Dams. The numeric TP targets range 0.023–0.029 mg/L for May–October and 0.024–0.030 mg/L for November–April. The numeric TN targets range 0.252–0.372 mg/L for May–October and 0.304–0.395 mg/L for November–April (NCRWQCB 2010a). These targets are based on the T4BSRN scenario (Appendix D, Section D-1) and are established as the monthly mean concentrations that allow achievement of the in-reservoir chlorophyll-*a* summer mean target of 10 µg/L, the *M. aeruginosa* cell density target of 20,000 cells/mL, and the microcystin target of 4 µg/L (NCRWQCB 2010a).

For multiple locations in the Klamath River, the TMDL model results indicate large daily variability in TP and TN that exceeds the small range in the monthly TMDL targets, particularly during summer and early fall (i.e., generally June–October) (Tetra Tech 2009). Therefore, the nutrient effects analysis considers whether a general downward (or upward) trend in TP and TN toward (or away from) the numeric targets would occur and, qualitatively, whether such a trend would support or alleviate the growth of nuisance and/or noxious phytoplankton or nuisance periphyton.

#### **3.2.4.2.2.3 Chlorophyll-*a* and Algal Toxins**

Within the area of analysis, Oregon possesses a numeric criterion for chlorophyll-*a* that is associated with the nuisance algae growth water quality objective and applies to natural lakes that do not thermally stratify, reservoirs, rivers, and estuaries (see Table 3.2-3).

The Klamath River TMDLs establish a chlorophyll-*a* target specific to the KHP of 10 µg/L during the growth season, based on a Nutrient Numeric Endpoint analysis (NCRWQCB 2010a). The Hoopa Valley Tribe has a chlorophyll-*a* criterion (150 mg/m<sup>2</sup>; see Table 3.2-6) for their periphyton density water quality objective, which is applicable to a short reach (≈RM 45–46) of the Klamath River upstream of the Trinity River. However, since effects of the Proposed Action on periphyton growth are addressed in Section 3.4, Algae, chlorophyll-*a* as a measure of periphyton density is not discussed further in the water quality effects analysis.

The Oregon criterion (15 µg/L) and the California TMDL target (10 µg/L) are used as chlorophyll-*a* thresholds of significance for J.C. Boyle Reservoir and Copco 1 and Iron Gate reservoirs, respectively. Anticipated regular exceedances of these thresholds would constitute a significant impact for this analysis.

For algal toxins, both Oregon and California have narrative water quality objectives for general toxicity (see Table 3.2-3 and 3.2-4). The Hoopa Valley Tribe has numeric

objectives for algal toxins (see Table 3.2-6). The WHO has set numeric thresholds for recreational exposures of microcystin toxin at 4 µg/L for a low probability of adverse health effects, and 20 µg/L for a moderate probability of adverse health effects (Falconer et al. 1999, Chorus and Cavalieri 2000). The WHO thresholds are general levels representing a variety of toxigenic cyanobacteria. Oregon has adopted public health guidelines for recreational exposures similar to the WHO values, and California uses the *Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms* (SWRCB 2010) developed jointly by the California Department of Public Health, SWRCB and OEHHA. To avoid conditions that lead to water quality impairments, the California Klamath River TMDLs use the WHO low probability of adverse health effects thresholds as targets specific to the California reaches of the KHP for *M. aeruginosa* and microcystin toxin (see Table 3.2-10).

**Table 3.2-10. Summary of Water Quality Guidance, Criteria, or Targets for Toxigenic Blue-Green Algae and Algal Toxins in the Area of Analysis**

Source	Description
Oregon <sup>1</sup>	
Public health guidelines for recreational exposure	40,000 cells/mL <i>M. aeruginosa</i> , or 8 µg/L microcystin
California <sup>2</sup>	
Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms	>100,000 cells/mL potentially toxigenic blue-green algae, or 40,000 cells/mL <i>M. aeruginosa</i> , or 8 µg/L microcystin
California Klamath River TMDL <sup>3</sup>	
Chl-a target for California KHP reservoirs (growth season)	< 20,000 cells/L <i>M. aeruginosa</i> , or < 4 ug/L microcystin
Hoopa Valley Tribe <sup>4</sup>	
<i>Microcystis aeruginosa</i> cell density	<5,000 cells/mL for drinking water <40,000 cells/mL for recreational water
Microcystin toxin Concentration	<1µg/L total microcystin for drinking water <8 µg/L total microcystin for recreational water
Total potentially toxigenic cyanobacteria species <sup>5</sup>	<100,000 cells/mL for recreational water

<sup>1</sup> Oregon DEQ (OAR 340-041): At these levels, water considered impaired.

<sup>2</sup> SWRCB (2010): At these levels, water considered impaired.

<sup>3</sup> NCRWQCB (2010a): These targets are set to avoid conditions that could lead to water quality impairments.

<sup>4</sup> HVTEPA (2008): At these levels, water considered impaired.

<sup>5</sup> Includes: Anabaena, Microcystis, Planktothrix, Nostoc, Coelosphaerium, Anabaenopsis, Aphanizomenon, Gloeotrichia, and Oscillatoria.

Since it is common to Oregon, California, and the Hoopa Valley Tribe (see Table 3.2-10), the  $< 8$  ug/L criterion for microcystin in recreational water is used as the threshold of significance for this Klamath Facilities Removal EIS/EIR. As is the case with chlorophyll-*a*, quantitative predictive tools for algal toxins are not available for the Proposed Action. Therefore, the algal toxin effects determinations are based on a qualitative assessment of whether the Proposed Action would result in exceedances of the criterion and adversely affect the human health recreational beneficial uses (REC-1, REC-2; Table 3.2-2). Growth conditions for toxigenic suspended algae (i.e., nutrient availability, impounded water) are considered as part of the qualitative analysis, where predicted increases in nutrient availability, water temperatures, and the availability of lacustrine (lake or reservoir) conditions would correspondingly increase algal toxin concentrations.

#### **3.2.4.2.2.4 Inorganic and Organic Contaminants**

Both Oregon and California have water quality objectives related to inorganic and organic contaminants. Oregon's toxicity objective has both a narrative and a numeric component (see Table 3.2-3); the numeric component has chemical-specific water-column criteria for freshwater and marine aquatic life and human health (CDM 2011). Oregon's numeric marine aquatic life criteria are not considered further because the Proposed Action would not affect the marine environment in Oregon. California's chemical constituents objective is numeric (listed in the Basin Plan [NCRWQCB 2006a], as noted in Table 3.2-4 and has chemical-specific water-column criteria for freshwater and marine aquatic life and human health, including bioaccumulative chemicals such as PCBs, methylmercury, dioxins, and furans (CDM 2011). California's toxicity and pesticides objectives are narrative (see Table 3.2-4). Hoopa Valley also has an ammonia toxicity objective based on pH and temperature (see Table 3.2-6). However, since available data collected to date suggests no actual ammonia toxicity events associated with the operation of the Four Facilities (NCRWQCB 2010a), this objective is not considered further.

Thresholds of significance for the Oregon and California narrative water quality objectives focus on designated beneficial uses and are applicable for contaminants in either the water column or the sediments. For this Klamath Facilities Removal EIS/EIR, establishment of toxicity and/or bioaccumulative potential for sediment contaminants relies upon thresholds developed through regional and state efforts such as the SEF for the Pacific Northwest (Appendix D, Section D.3). The SEF includes bulk sediment screening levels for standard chemicals of concern and chemicals of special occurrence in marine and freshwater sediments for Idaho, Oregon, and Washington (RSET 2009). Additionally, Oregon has developed bioaccumulation screening level values that are used for this Klamath Facilities Removal EIS/EIR analysis. Similar numeric chemical guidelines for the assessment and characterization of freshwater and marine sediments do not exist for California. Additional information regarding applicable sediment screening levels used for the Secretarial Determination sediment evaluation process is presented in CDM (2011).

Impacts on water quality would be considered significant if results of sediment and elutriate chemical analyses and biological testing indicate that at least one chemical is detected at a level with potential for significant adverse effects based on multiple lines of evidence (CDM 2011). This evaluation is not intended to be equivalent to the SEF process.

### **3.2.4.3 Effects Determinations**

#### **3.2.4.3.1 Alternative 1: No Action/No Project Alternative**

Under this Alternative, the Klamath Hydroelectric Project would continue current operations under the terms of an annual license until a long-term license is finalized. Some restoration actions have already been initiated and would continue under the No Action. These include the Williamson River Delta Project, the Agency Lake and Barnes Ranch Project, fish habitat restoration work, and ongoing climate change assessments. The TMDLs would still be implemented under this and all other alternatives as they are an unrelated regulatory action. Hydroelectric operations would continue as they have been, providing peaking power generation during the summer as demand requires and conditions allow. The No Action/No Project Alternative would leave the Four Facilities in place. In the Upper Klamath Basin, this would only affect water quality in the Hydroelectric Reach; however, resource management actions elsewhere in the Upper Klamath Basin (i.e., Upper Klamath Lake and tributaries) are also analyzed under this alternative because they would potentially affect water quality further downstream.

#### **3.2.4.3.1.1 Water Temperature**

##### **Upper Klamath Basin**

*Continued impoundment of water at the Four Facilities could result in short-term and long-term seasonal water temperatures that are shifted from the natural thermal regime of the river and do not meet applicable ODEQ and California Basin Plan water quality objectives and adversely affect beneficial uses in the Hydroelectric Reach.* Under existing conditions, water temperatures (measured as 7-day-average maximum values) in much of the reach from Upper Klamath Lake to the Oregon-California state line exceed 20°C (68°F) in June through August and result in non-attainment of the fish and aquatic life beneficial use for spawning and rearing of salmon, steelhead, and trout, as well as core coldwater habitat (see Table 3.2-3). The exception to this occurs in the J.C. Boyle Bypass Reach where cold groundwater springs enter the river at a relatively constant 11-12°C (Kirk et al. 2010). Due to the constant groundwater input, there is also little daily fluctuation in water temperatures in this reach. Just downstream, in the J.C. Boyle Peaking Reach, water temperatures fluctuate on a daily basis due to powerhouse peaking flows. When peaking flows are not occurring, water in the Peaking Reach is dominated by cooler water from the upstream groundwater springs. When peaking flows from J.C. Boyle Reservoir enter the reach, water temperatures can increase by several degrees (PacifiCorp 2006b). Further downstream in the California portions of the Klamath River, summer MWMTs throughout the Hydroelectric Reach regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support in California (NCRWQCB 2010a) and result in non-attainment of designated COLD and WARM beneficial uses (see Table 3.2-4)

Under the No Action/No Project Alternative, several ongoing resource management actions in the Upper Klamath Basin represent reasonably foreseeable actions related to water temperature within the period of analysis (50 years). Underway since 2007, the Williamson River Delta Project is intended to restore wetlands for endangered fish species and improve water quality in Upper Klamath Lake (see Section 2.3.1). Thus far, the project has involved breaching over two miles of agricultural levees along the Williamson River where it flows into Upper Klamath Lake, restoring approximately 3,500 acres of wetlands in 2007 and an additional 1,400 acres in 2008. One of the project goals is to create wetlands with warmer spring water temperatures for rearing fish in the wetlands (as compared to cooler temperatures in the Williamson River or Upper Klamath Lake). The Agency Lake and Barnes Ranches Project would use historically diked and drained portions of the Barnes Ranches as interim pumped water storage areas, ultimately reconnecting them to Agency Lake (see Section 2.3.1). Breaching the dikes would convert the current 63,770 acre feet pumped storage to passive storage in Upper Klamath Lake. Specific options still need to be developed and studied as part of a separate project-level National Environmental Policy Act (NEPA) evaluation and Endangered Species Act (ESA) consultation. At a programmatic level, these activities may improve springtime water temperatures for spawning and rearing of fish in Upper Klamath Lake and tributaries to the lake. Additional resource management actions related to spring, summer, and fall water temperatures that are ongoing in tributaries to Upper Klamath Lake (see Section 2.3.1) include the following:

- Floodplain rehabilitation
- Large woody debris replacement
- Riparian vegetation planting
- Purchase of conservation easements and/or land

Although these resource management actions would improve water temperatures in the Upper Klamath Basin under the No Action/No Project Alternative, the effects would only be local and would not measurably improve water temperatures in the Hydroelectric Reach. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation measures focused on water temperature in the Upper Klamath Lake Drainage TMDL and those in the Upper Klamath River and Lost River Sub-basins TMDLs would improve water temperatures in the Hydroelectric Reach. The Oregon TMDLs include heat load allocations for anthropogenic and background nonpoint sources, where effective shade and channel morphology targets are used as surrogate measures for controlling nonpoint source temperature loading (see Section 3.2.2.4).

To support beneficial uses in California, the North Coast Basin Plan stipulates that water temperature can not be increased by more than 2.8°C (5°F) above natural receiving temperatures (see Table 3.2-4). The NCRWQCB has determined that natural receiving water temperatures in the Klamath River are already too warm to support designated beneficial uses. Therefore, the Klamath TMDL allocates a daily average (and daily



maximum) increase in water temperatures of 0.5°C [0.9°F] for Copco 1 and 2 reservoir tailraces and 0.1°C [0.18°F] for the Iron Gate Reservoir tailrace. This allocation is designed to alleviate the late summer/fall 2–10°C (3.6–18°F) warming caused by the reservoirs immediately downstream of Iron Gate Dam under existing conditions (see Section 3.2.3.2). Additionally, a compliance lens in Copco 1 and Iron Gate Reservoirs must be maintained, such that water temperature and dissolved oxygen conditions would be suitable for cold water fish in the reservoirs during the critical summer period (see Section 3.2.2.4). To date, no proposed action has been identified by PacifiCorp to achieve the temperature allocations assigned to Copco 1 and Iron Gate reservoirs.

The Klamath TMDL model (see Appendix D) indicates that under the No Action/No Project Alternative (similar to the TMDL T4BSRN scenario) water temperatures in the reach from Link River Dam to just upstream of J.C. Boyle Reservoir (including Keno Impoundment and Lake Ewauna) and in the Hydroelectric Reach would be very similar to modeled natural conditions temperatures (TMDL T1BSR scenario) (NCRWQCB 2010a). While the Klamath TMDL model output also indicates that natural conditions would exceed the 16°C (60.8°F) numeric water quality objective for the support of core coldwater habitat in Oregon during June–October (see Table 3.2-3), the narrative Oregon standard stipulates that the natural conditions criterion would supersede the numeric criterion. Thus, assuming eventual full attainment of the Oregon and California TMDLs, water temperature objectives in the Klamath Hydropower Reach can be met; however, the timeframes for achieving water temperature allocations required under the TMDLs will depend on the measures taken to improve water quality conditions. Full attainment could require decades to achieve.

The TMDL models do not address the potential effects of global climate change on water temperatures in the Klamath Basin (Appendix D). Within the period of analysis (i.e., 50 years), climate change models for the region suggest that as the western United States warms, air temperatures will increase, there will be a slight increase in overall precipitation, winter snowfall will likely shift to higher elevations, and snowpack will be diminished as more precipitation falls as rain (Oregon Climate Change Research Institute [OCCRI] 2010; see also Section 3.10.3.1). For the Sprague River watershed, increased flooding earlier in the spring and decreased summer baseflow would occur as a consequence of increased and decreased proportions of rainfall and snowfall, respectively, given climate change projections (Risley 2010). In the Klamath Basin as a whole, increasing air temperatures and decreasing flows in the summer months would be expected to cause general increases in summer and fall water temperatures on the order of 2–3°C (3.6–5.4°F) (Bartholow 2005) (see also discussion under Lower Klamath Basin).

As part of the Klamath Dam Removal Secretarial Determination studies, the effects of climate change were included in model projections for future water temperatures under the No Action/No Project Alternative and the Proposed Action. RBM10 model results using climate change predictions from five GCMs indicate that future water temperatures under the No Action/No Project Alternative (where simulated flows are subject to the 2010 Biological Opinion mandatory flow regime [NOAA Fisheries Service 2010]) would be 1–2.3 °C (1.8–4.1 °F) warmer than historical temperatures in the Klamath Basin (Perry

et al. 2011). While this temperature range is slightly lower than that suggested using the Bartholow (2005) historical estimates, within the general uncertainty of climate change projections, the two modeling efforts correspond reasonably well and indicate that water temperatures in the Upper Klamath Basin are expected to increase with the period of analysis on the order of 1–3°C (1.8–5.4°F).

The anticipated increases in water temperatures due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Upper Klamath Basin. The magnitude of the opposition would be slightly less than, but within the general range of, late summer/fall improvements (2–10°C [3.6–18°F]) expected by the TMDLs immediately downstream of Iron Gate Dam (see discussion under Lower Klamath Basin), such that climate change would partially offset the anticipated TMDL-related improvements.

**Existing late summer/fall water temperatures in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanisms and timing unknown) would significantly improve conditions in the Hydroelectric Reach, but climate change would partially offset TMDL-related improvements in the late summer/fall. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### Lower Klamath Basin

*Continued impoundment of water at the Four Facilities could result in short-term and long-term seasonal water temperatures that are shifted from the natural thermal regime of the river and do not meet applicable California North Coast Basin Plan water quality objectives and adversely affect beneficial uses in the Klamath River downstream of Iron Gate Dam.* Under existing conditions, the Four Facilities alter the natural thermal regime of the river by cooling springtime water temperatures 1–2.5°C (1.8–4.5°F) and warming late summer/fall water temperatures 2–10°C (3.6–18°F) in the lower Klamath River, with the largest effects occurring just downstream of Iron Gate Dam (RM 190.1) (PacifiCorp 2004a, Duns Moor and Huntington 2006, NCRWQCB 2010a, Perry et al. 2011). Effects diminish with distance downstream such that they are not discernable by the Salmon River (RM 66) (see Section 3.2.3.2 and Appendix C for more detail). Summer MWMTs in the Klamath River downstream of Iron Gate Dam to the Salmon River regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support in California (NCRWQCB 2010a) and result in non-attainment of designated COLD and WARM beneficial uses (see Table 3.2-4). Although not an effect of the reservoirs at the Four Facilities, MWMTs in the mainstem from the Salmon River to the Klamath Estuary also regularly exceed these thresholds and result in non-attainment of these beneficial uses (see Section 3.2.3.2 and Appendix C for more detail).

Within the period of analysis (i.e., 50 years), implementation of NOAA Fisheries Service 2010 Biological Opinion mandatory flows and CDFG Code Section 5937 instream flow mandate for tributaries to the mainstem Klamath River (see Section 2.3.1 and Section 3.2.4.1, No Action/No Project Alternative) would increase seasonal stream flow and

would be expected to moderately decrease water temperatures in the Klamath River downstream of Iron Gate Dam, particularly during summer and fall months. The California Klamath River TMDLs were developed based on compliance with water quality objectives at the Oregon-California state line, meaning that successful implementation of water quality improvement measures under the Oregon TMDLs will improve water temperatures in the Lower Klamath Basin as well. General implementation measures under the California Klamath TMDLs associated with water temperature improvements are described in the prior section for the Upper Klamath Basin and in Section 3.2.2.4. Additionally, the Shasta, Scott, and Salmon Rivers, tributaries to the lower Klamath River, have TMDLs addressing temperature (see Section 3.2.2.4).

The Klamath TMDL model indicates that under the No Action/No Project Alternative (similar to TMDL T4BSRN scenario), water temperatures from Iron Gate Dam (RM 190.1) to the Klamath Estuary (RM 0-2) would improve towards modeled natural conditions (similar to the TMDL T1BSR scenario) (NCRWQCB 2010a). Some delayed warming of springtime water temperatures (February-March) and delayed cooling of late summer/fall (August-November) water temperatures would still occur under the No Action/No Project Alternative due to the large thermal mass of Copco 1 and Iron Gate reservoirs. This temporal shift may continue to occur under the No Action/No Project Alternative from downstream of Iron Gate Dam to approximately Seiad Valley (RM 129.4) because while full attainment of the California Klamath TMDLs would improve water temperature, the model is unable to demonstrate full temperature compliance in the spring and fall downstream of Iron Gate Dam to Seiad Valley with the Four Facilities in place. Based on TMDL model results, water temperature from Seiad Valley (RM 129.4) to the Salmon River (RM 66.0) (the approximate location at which the reservoir temperature signal no longer persists under existing conditions), would meet water quality objectives. The model-predicted lack of compliance from Iron Gate Dam to Seiad Valley underlies the TMDL requirement for PacifiCorp to develop a Reservoir Management Plan that specifically addresses water temperature and dissolved oxygen improvements that would allow the Four Facilities to meet water quality objectives (NCRWQCB 2010a). The timeframes for achieving water temperature allocations required under these TMDLs will depend on the measures taken to improve water quality conditions. It is anticipated that full attainment of the TMDLs would require decades to achieve.

General climate change effects are discussed in Section 3.10.3.1. With respect to water temperatures in the Lower Klamath Basin, the historical data record indicates that mainstem water temperatures have increased approximately 0.05°C (0.09°F) per year between 1962 and 2001 (Bartholow 2005) such that climate change may already be affecting Klamath River water temperatures. Projecting the Bartholow (2005) estimate of an average annual temperature increase 50 years into the future, water temperatures would increase 2–3°C (3.6–5.4°F) by the end of the analysis period. As part of the Klamath Dam Removal Secretarial Determination studies, the effects of climate change were included in model projections for future water temperatures under the No Action/No Project Alternative and the Proposed Action. RBM10 model results using climate change predictions from five GCMs indicate that future water temperatures under the No

Action/No Project Alternative (where simulated flows are subject to the 2010 Biological Opinion mandatory flow regime [NOAA Fisheries Service 2010]) would be 1–2.3 °C (1.8–4.1 °F) warmer than historical temperatures (Perry et al. 2011). While this temperature range is slightly lower than that suggested using the Bartholow (2005) historical estimates, within the general uncertainty of climate change projections, the two projections correspond reasonably well and indicate that water temperatures in the Lower Klamath Basin are expected to increase with the period of analysis on the order of 1–3°C (1.8–5.4°F).

The anticipated increases in water temperatures due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Lower Klamath Basin. Within the range of late summer/fall improvements expected by the TMDLs (2–10°C [3.6–18°F] immediately downstream of Iron Gate Dam and 2–5°C [3.6–9°F] just upstream of the Scott River), climate change would partially offset the anticipated TMDL-related improvements. Climate change would also completely offset the existing 1–2°C springtime cooling effect of the reservoirs; the cooling effect in spring is potentially beneficial to rearing salmonids by reducing stress and disease for late outmigrants.

**Existing late summer/fall water temperatures in the Klamath River from immediately downstream of Iron Gate Dam to the Salmon River (RM 66) are adverse<sup>5</sup>. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve conditions but water temperatures from Iron Gate Dam to approximately Seiad Valley (RM 129.4) would remain adverse. Climate change would partially offset TMDL-related improvements in the late summer/fall. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### **3.2.4.3.1.2 Suspended Sediments**

##### **Upper Klamath Basin**

*Continued impoundment of water at the Four Facilities could result in short-term and long-term interception and retention of mineral (inorganic) suspended material by the KHP dams.* Under existing conditions, peak concentrations of this suspended material occur during winter and spring (November through April) due to runoff and tributary flows to the Hydroelectric Reach associated with high-flow events. The KHP dams intercept and trap suspended materials such that water column concentrations generally decrease with distance downstream in the Hydroelectric Reach (see Section 3.2.3.3). While this may be potentially beneficial for downstream reaches by decreasing TSS concentrations and turbidity, the trapping of fine sediments and suspended materials does not appear to be a critical function with respect to the overall sediment delivery for the Klamath Basin (see also Section 3.11.3.3 for a discussion of basin sediment supply and transport). A relatively small (3.4 percent) fraction of total sediment supplied to the

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<sup>5</sup> Water temperatures from the Salmon River to the Klamath Estuary are also adverse but this condition is not a result of the impoundment of water in the reservoirs at the Four Facilities.

Klamath River on an annual basis originates from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) (see Section 3.2.3.3) and beneficial uses in the upper Klamath River are currently not impaired due to mineral (inorganic) suspended material (see Table 3.2-8).

Under the No Action/No Project Alternative, the ongoing Williamson River Delta Project and Agency Lake and Barnes Ranches Project would contribute to reduced mineral (inorganic) fine sediment inputs to Upper Klamath Lake. In the tributaries to Upper Klamath Lake, additional resource management actions for fish habitat restoration (see Section 2.4.2) related to mineral (inorganic) sediment are ongoing, including the following:

- Floodplain rehabilitation
- Large woody debris replacement
- Cattle exclusion [fencing]
- Riparian vegetation planting
- Mechanical thinning of upland areas and fire treatment
- Purchase of conservation easements/land
- Road decommissioning
- Reduction of fine sediment sources

These resource management actions are also discussed with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

Anticipated climate change effects within the period of analysis (i.e., 50 years) include increased fine sediment delivery to streams due to more intense and frequent precipitation events and elevated stormwater runoff (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections). The anticipated increases would occur over a timescale of decades and may reduce anticipated improvements expected from successful implementation of the aforementioned resource management actions; however, the magnitude of the increased sediment delivery relative to the currently low levels of fine sediment production has not been assessed.

**Existing interception and retention of mineral (inorganic) suspended material in the reservoirs in the Hydroelectric Reach is potentially beneficial. Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would result in no change from existing conditions.**

*Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in short-term (one year) increases in mineral (inorganic) suspended material in the Hydroelectric Reach.* Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking reaches in the fall of 2011 using a passive approach before high flow periods, or to provide for other habitat enhancement in the Klamath River upstream of Copco 1 Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous

species following dam removal. Work on IM 7 began in fall 2010 with the contracting, planning, and permitting phase. Passive gravel placement is specified by IM 7, which would avoid in-stream placement of gravel and would limit turbidity increases to periods of high river flow when turbidity is naturally elevated. The potential for sediments to enter the water during gravel placement along the river banks can be minimized or eliminated downstream of the enhancement sites through the implementation of BMPs for construction activities (Appendix B) (BLM 2011). Any disturbed sediments would be trapped by Iron Gate Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. **Under the No Action/No Project Alternative, the effect of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, on SSCs in the Hydroelectric Reach would be a less-than-significant impact.**

*Implementation of IM 8, J.C. Boyle Bypass Barrier Removal, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach due to deconstruction activities.* Under this IM, the sidecast rock barrier located approximately three miles upstream of the J.C. Boyle Powerhouse in the J.C. Boyle Bypass Reach would be removed. The objective of IM 8 is to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead, Pacific lamprey, and redband trout. The potential for sediments to enter the water during in-stream work associated with barrier removal and from construction site runoff could be minimized or eliminated through the implementation of BMPs for construction activities (Appendix B). Any disturbed sediments would be trapped by Copco 1 Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. **Under the No Action/No Project Alternative, the effect of IM 8, J.C. Boyle Bypass Barrier Removal, on SSCs in the Hydroelectric Reach in the J.C. Boyle bypass reach would be a less-than-significant impact.**

*Continued impoundment of water at the Four Facilities could result in short-term and long-term seasonal (April through October) increases in algal-derived (organic) suspended material in the Hydroelectric Reach due to in-situ algal blooms.* Under existing conditions, episodic increases in suspended material occur in the KHP reservoirs during summer months as a result of *in-situ* algal productivity. These concentrations typically range 10–20 mg/L, but can be greater than 200 mg/L (see Section 3.2.3.3) and cause nuisance or adversely affect beneficial uses during intense blooms. While some settling of algal-derived (organic) suspended materials from Upper Klamath Lake may occur in the reservoirs at the Four Facilities, the majority of removal occurs further upstream in the Keno Impoundment, with some additional decreases in concentration due to mechanical breakdown of algal remains in the turbulent river reaches between Keno Dam and Copco 1 Reservoir, and dilution from the springs downstream of J.C. Boyle Dam (see Appendix C for more detail). The high levels of seasonal suspended material caused by algal blooms in the reservoirs in the Hydroelectric Reach would continue to occur under the No Action/No Project Alternative.

Also under this alternative, the ongoing Williamson River Delta Project and Agency Lake and Barnes Ranches Project would contribute to reduced fine sediment inputs to

Upper Klamath Lake. At a programmatic level, the fine sediment reductions may decrease overall sediment-associated phosphorus inputs to the lake and downstream reaches. The effects would be mostly local, but may indirectly reduce nutrient concentrations in the Hydroelectric Reach by decreasing concentrations in upstream Upper Klamath Lake. In the tributaries to Upper Klamath Lake, additional resource management actions for fish habitat restoration (see Section 2.4.2) related to sediment-associated phosphorus are ongoing, including the following:

- Floodplain rehabilitation
- Cattle exclusion [fencing]
- Riparian vegetation planting
- Mechanical thinning of upland areas and fire treatment
- Purchase of conservation easements/land
- Road decommissioning

These resource management actions are also discussed with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

Full attainment of the measures in Oregon's Upper Klamath River and Lost River TMDLs may indirectly decrease algal-derived suspended material in the Link River and Klamath River upstream of the Oregon-California state line within the period of analysis (i.e., 50 years). The Oregon draft TMDLs require reductions in phosphorus and nitrogen loading from both point sources and nonpoint sources in the Upper Klamath River to address chlorophyll-*a* impairments (see Section 3.2.2.4, Upper Klamath River and Lost River TMDLs). Decreases in nutrient inputs to the upper Klamath River would decrease algal blooms and decrease algal-derived suspended material in this reach. Full attainment of the California Lower Lost River for pH and nutrients and the Klamath River TMDLs for organic enrichment/low dissolved oxygen, nutrients, and microcystin water quality impairments would decrease algal-derived suspended material in the Klamath River downstream of the Oregon-California state line to Iron Gate Reservoir and would, in the long-term, be beneficial to water quality. It is anticipated that full attainment of the Oregon and California TMDLs would require decades to achieve.

Anticipated climate change effects within the period of analysis (i.e., 50 years) include longer and more intense algal blooms due to increased air temperatures (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections) and higher overall rates of photosynthesis during summer months. This may increase levels of algal-derived (organic) suspended material. The anticipated increases in suspended material due to climate change would also occur over a timescale of decades and may reduce anticipated improvements expected from successful TMDL implementation throughout the Upper Klamath Basin; however, the magnitude of the increased algal productivity with increasing temperature has not been assessed.

**Existing seasonal increases in algal-derived (organic) suspended material in the reservoirs in the Hydroelectric Reach are adverse. Full attainment of the Oregon**

**and California TMDLs (implementation mechanism and timing unknown) would significantly decrease algal blooms and associated suspended material in the reservoirs in this reach. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### Lower Klamath Basin

*Continued impoundment of water at the Four Facilities could result in short-term and long-term interception and retention of mineral (inorganic) sediments by the dams and correspondingly low levels of suspended material immediately downstream of Iron Gate Dam.* Under existing conditions, during November–April, mineral (inorganic) suspended sediments tend to be <100 mg/L in the Klamath River immediately downstream of Iron Gate Dam, increasing to levels greater than 150 mg/L in the mainstem downstream of the confluence with the Trinity River during storm events (see Section 3.2.3.3). While the interception and retention of mineral (inorganic) suspended sediments may be moderately beneficial for the Klamath River immediately downstream of Iron Gate Dam, this represents a very minor portion of the load with respect to overall sediment delivery for the Klamath Basin. A relatively small (3.4 percent) fraction of total sediment supplied to the Klamath River on an annual basis, originates from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) (see Section 3.2.3.3) and beneficial uses in the Klamath River immediately downstream of Iron Gate Dam are currently not impaired due to mineral (inorganic) suspended material (see Table 3.2-8).

The Klamath River from the Trinity River (RM 42.5) to the mouth (RM 0) is listed as sediment impaired (see Table 3.2-8), and while the California Klamath River TMDLs do not explicitly address sediment impairments, they do identify allocations to address temperature impairments caused by excessive (primarily inorganic) sedimentation (see Section 3.2.2.4, Klamath River TMDLs). Additionally, the Trinity River and South Fork Trinity River TMDLs, which are outside of the area of analysis for the Proposed Action and alternatives, are expected to affect water quality in the lower Klamath River. These TMDLs include a specific focus on sediment improvements. Further, the Scott River TMDL addresses sediment. General measures under the Trinity, South Fork Trinity, and Scott Rivers' TMDLs that can be associated with (primarily mineral) suspended sediment loads are described briefly in Section 3.2.2.4.

Full attainment of the measures in the Trinity River, South Fork Trinity River, and Scott River TMDLs would decrease (primarily mineral) suspended sediment loads in the sediment impaired reach of the lower Klamath River from the Trinity River (RM 40) to the mouth (RM 0) and would, in the long-term, be beneficial to water quality. Full attainment could require decades to achieve. These implementation measures would occur downstream of the Four Facilities and are not related to the KHP reservoirs under the No Action/No Project Alternative.

Anticipated climate change effects within the period of analysis (i.e., 50 years) include increased fine sediment delivery to streams due to more intense and frequent precipitation events and elevated stormwater runoff (Barr et al. 2010) (see Section 3.10.3.1, Existing



Conditions – Climate Change Projections). The anticipated increases would occur over a timescale of decades and may reduce improvements expected from successful implementation of the aforementioned TMDL implementation actions; however, the magnitude of the increased sediment delivery relative to the currently low levels of fine sediment production has not been assessed.

**Existing interception and retention of mineral (inorganic) sediments by the dams is potentially beneficial. Continued impoundment of water in the reservoirs at the Four Facilities under the No Action/No Project Alternative would result in no change from existing conditions.**

*Continued impoundment of water at the Four Facilities could result in short-term and long-term seasonal (April through October) increases in algal-derived (organic) suspended material in the reservoirs in the Hydroelectric Reach and transport into the Klamath River downstream of Iron Gate Dam.* Under existing conditions, concentrations of summer and fall (June–October) algal-derived (organic) suspended material in the Klamath immediately downstream of Iron Gate Dam tend to be less than 5–8 mg/L, reflecting the dams’ capacity to intercept and retain suspended material. Much of the algal-derived (organic) suspended material retained behind the Project dams is a result of in-reservoir algal production, as the majority (although not all) of the algal material transported downstream from Upper Klamath Lake appears to be intercepted in the Keno Impoundment (see Appendix C for more detail). However, some of the seasonal algal production that occurs in Copco 1 and Iron Gate Reservoirs is transported downstream to the Klamath River, as evidenced by chlorophyll-*a* patterns, and to a lesser degree TSS patterns, in the river from Iron Gate Dam to the Klamath Estuary (see Appendix C for more detail). While the transport occurs, TSS levels are still relatively low. This pattern would continue to occur under the No Action/No Project Alternative.

Full attainment of the measures in Oregon’s Upper Klamath River and Lost River TMDLs would decrease algal blooms and decrease algal-derived suspended material in the KHP reservoirs due to decreasing nutrient availability. Full attainment of the measures in California’s Lower Lost River TMDLs and Klamath River TMDLs for organic enrichment/low dissolved oxygen, nutrients, and microcystin water quality impairments, would also decrease algal-derived suspended material KHP reservoirs and would, in the long-term, be beneficial to water quality. It is anticipated that full attainment of the Oregon and California TMDLs would require decades to achieve.

Anticipated climate change effects within the period of analysis (i.e., 50 years) include increased fine sediment delivery to streams and earlier, longer, and more intense algal blooms (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections), which may increase levels of both mineral (inorganic) and algal-derived (organic) suspended material, the latter due to higher overall rates of photosynthesis during summer months. The anticipated increases in suspended sediments due to climate change would also occur over a timescale of decades and may reduce improvements expected from successful TMDL implementation throughout the Lower Klamath Basin; however, the magnitude of the opposition is unknown.

**Existing transport of seasonally high algal-derived (organic) suspended material from the reservoirs to the Klamath River downstream of Iron Gate Dam is adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve conditions. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### **3.2.4.3.1.3 Nutrients**

##### Upper Klamath Basin

*Continued impoundment of water at the Four Facilities could result in long-term interception and retention of TN and TP in the Hydroelectric Reach on an annual basis but release (export) of TP and TN from reservoir sediments on a seasonal basis.* Under existing conditions, TN and TP decrease longitudinally through the Hydroelectric Reach on an annual basis due to dilution from the springs downstream of J.C. Boyle Dam and the settling of algal-derived (organic) material and associated nutrients in Copco 1 and Iron Gate reservoirs. On a seasonal basis, reservoir sediments can release bioavailable TP (as ortho-phosphorus), and to a lesser degree, bioavailable TN (as ammonium), to the water column during periods of seasonal hypolimnetic anoxia (see Section 3.2.3.4). While much of the TP released from anoxic reservoir sediments appears to remain within the hypolimnion until the reservoirs begin to turn over in the fall, some release does occur during late summer and fall months when it could stimulate in-reservoir algal blooms. Nutrients infrequently meet narrative Oregon water quality objectives for nuisance algae growth (Oregon Administrative Rule [OAR] 340-041-0019), or the narrative California North Coast Basin Plan water quality objective for biostimulatory substances (see Table 3.2-4) in the Hydroelectric Reach.

Under the No Action/No Project Alternative, the ongoing Williamson River Delta Project and Agency Lake and Barnes Ranches Project (see above water temperature and suspended sediment discussions) would provide long-term reductions in nutrients transported from the Agency Lake subbasin to Upper Klamath Lake. While short-term releases of nutrients are possible during the establishment of project equilibrium, at a programmatic level, these activities may decrease overall nutrient inputs to Upper Klamath Lake by inundating wetland (peat) soils and creating anaerobic conditions that support nutrient retention, particularly in the case of phosphorus (Snyder and Morace 1997). The effects would be mostly local, but may indirectly reduce nutrient concentrations in the Hydroelectric Reach by decreasing upstream nutrient concentrations in Upper Klamath Lake. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3.2, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation of water quality improvement measures addressing nutrients in the Upper Klamath Lake Drainage TMDL and Water Quality Management Plan (WQMP) and the Upper Klamath River and Lost River Sub-basins TMDL and WQMP (see Section 3.2.2.4), include the following:

- Achievement of TMDL targets for TP loading as the primary method of improving dissolved oxygen (and pH) conditions in Upper Klamath and Agency lakes
- Reductions in phosphorus, nitrogen, and BOD loading from both point and nonpoint (e.g., agricultural returns) sources in the Upper Klamath River

In addition to the Oregon upstream improvements, California possesses load allocations for the Lower Lost River TMDLs for pH and nutrients and specific TMDL load allocations for TN and TP assigned to the KHP facilities for the Klamath River TMDLs. The California Klamath River TMDL also indicates that “alternative pollutant load reductions and/or management measures or offsets that achieve the in-reservoir targets” are possible (NCRWQCB 2010a).

The Oregon and California TMDLs in the Upper Klamath Basin are designed to meet water quality objectives; however, the timeframes for achieving nutrient allocations required under these TMDLs will depend on the measures taken to improve water quality conditions. Klamath TMDL model results for nutrient species (i.e., ortho-phosphorus, nitrate, and ammonium) are highly variable depending on location and season, likely due to rapid uptake and release of these chemical species during and following seasonal algal blooms (see Section 3.2.3.1) and potentially due to peaking operations at the J.C. Boyle Powerhouse. Nonetheless, TMDL modeling results tend to suggest that concentrations under the No Action/No Project Alternative would be similar to modeled natural conditions in the Hydroelectric Reach in spring and summer assuming full attainment of the TMDLs. Full attainment could require decades to achieve and is highly dependent on nutrient loads exiting Upper Klamath Lake and on agricultural return flows along the Keno Reach.

In summary, despite beneficial annual decreases in TP and TN through the Hydroelectric Reach, on a seasonal basis, internal release and export of TP, and to a lesser degree TN, from anoxic reservoir sediments during the summer and late fall may contribute to large blooms of toxigenic algae in the reservoirs.

**Existing interception and retention of nutrients in the reservoirs on an annual basis is beneficial, but the release (export) of nutrients (particularly TP) from reservoir sediments on a seasonal basis is adverse for the Hydroelectric Reach. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease nutrients. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### Lower Klamath Basin

*Continued impoundment of water at the Four Facilities could result in long-term interception and retention of TP and TN in the KHP reservoirs on an annual basis and release (export) of TP and TN to the Klamath River downstream of Iron Gate Dam on a seasonal basis. On an annual basis, nutrients in the Klamath River downstream of Iron Gate Dam currently tend to be lower than those in upstream reaches, due to dilution from*

the natural springs downstream of J.C. Boyle Dam and settling of particulate matter and associated nutrients in the larger KHP reservoirs (see Section 3.2.3.4). Further decreases in nutrient levels occur with distance downstream of Iron Gate Dam due to a combination of tributary dilution and in-river nutrient removal processes (see Section 3.2.3.4).

Although interception and retention of nutrients in the KHP reservoirs on an annual basis may be beneficial to the Klamath River downstream of Iron Gate Dam, under existing conditions TP and TN concentrations from the dam to the Klamath Estuary during late summer/early fall do not meet the narrative California Basin Plan water quality objective for biostimulatory substances due to the promotion of algal growth at levels that cause nuisance effects or adversely affect beneficial uses (see Table 3.2-4), nor do they meet the Hoopa Valley Tribe numeric criteria for TP (0.035 mg/L) and TN (0.2 mg/L) (see Table 3.2-6). Further, in late-summer and fall (i.e., August-November), TP and TN concentrations can increase downstream of the KHP reservoirs due to release of TP (as ortho-phosphorus) and, to a lesser degree, TN (as ammonium), which are formed during periods of seasonal hypolimnetic anoxia in Copco 1 and Iron Gate reservoirs. This seasonal release occurs during periods that may stimulate periphyton growth in the Klamath River downstream of Iron Gate Dam (see Appendix C, Sections C.3.1.4 C.3.2.1). This pattern would continue under the No Action/No Project Alternative.

In the Lower Klamath Basin, the California Klamath TMDLs include a specific focus on nutrient (TN and TP) improvements through specific load allocations assigned to the KHP facilities in California – Copco and Iron Gate reservoirs (see Section 3.2.2.4). Although specific nutrient allocations are only assigned to the KHP, the California Klamath TMDLs were developed based on compliance with water quality objectives at the Oregon-California state line, meaning that successful implementation of water quality improvement measures under the Oregon TMDLs will improve nutrients in the Lower Klamath Basin as well. General measures under the California Klamath River TMDLs that are associated with nutrients include the following:

- Developing a conditional waiver by 2012 to control discharges from agricultural activities (e.g., grazing, irrigated agriculture)
- Prohibiting the unauthorized discharge of waste that is in violation of water quality standards

The Shasta River TMDLs also address nutrients (see Section 3.2.2.4).

Full attainment of the measures in the Oregon and California TMDLs would result in waters meeting water quality standards; however, the timeframes for achieving nutrient allocations required under these TMDLs will depend on the measures taken to improve water quality conditions. Modeling conducted for development of the California Klamath River TMDLs indicates that under the No Action/No Project Alternative (similar to the T4BSRN scenario) TN and TP in the Klamath River downstream of Iron Gate Dam would meet or be lower than modeled natural conditions due to the trapping efficiency of sediment- and algal-associated nutrients behind the dams. Nutrient levels would also meet Hoopa Valley Tribe criteria for TP (0.035 mg/L) and TN (0.2 mg/L) (NCRWQCB 2010a). Given full attainment of the measures in the Oregon and California

TMDLs, actual TN concentrations under the No Action/No Project Alternative and natural conditions might be slightly lower than the model predicted concentrations, because denitrification is not included as a possible nitrogen removal term in the riverine segments of the Klamath TMDL model (Tetra Tech 2009). Nutrient species (i.e., ortho-phosphorus, nitrate, ammonium) concentrations are variable depending on location and season, with particularly high daily variation during summer months, but Klamath TMDL model results tend to suggest that concentrations under the No Action/No Project Alternative would be somewhat higher than modeled natural conditions in the Lower Klamath Basin. Use of adaptive management will be employed to refine efforts toward achieving water quality standards and TMDL targets. It is anticipated that full attainment of the TMDLs would require decades to achieve.

**Existing interception and retention of nutrients in the reservoirs on an annual basis is beneficial, but the release (export) of nutrients (particularly TP) on a seasonal basis is adverse for the Klamath River downstream of Iron Gate Dam. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease nutrients. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### **3.2.4.3.1.4 Dissolved Oxygen**

##### Upper Klamath Basin

*Continued impoundment of water at the Four Facilities could result in long-term seasonal and daily variability in dissolved oxygen concentrations in the Hydroelectric Reach, such that levels do not meet ODEQ and California North Coast Basin Plan water quality objectives and adversely affect beneficial uses.* Under existing conditions, dissolved oxygen levels exhibit summer and fall levels substantially below water quality objectives and infrequently support designated beneficial uses in Oregon for coldwater aquatic life, cool water aquatic life, warm water aquatic life, and spawning (including bull trout spawning and juvenile rearing, core cold-water habitat, redband trout, and cool water species [no salmonid use]; see Table 3.2-3), and in California for COLD, WARM, and SPWN beneficial uses (see Table 3.2-4). Dissolved oxygen levels are particularly low during the summer in the reach from Link River Dam to upstream of J.C. Boyle Reservoir (including Keno Impoundment and Lake Ewauna), with typical levels ranging from <1 mg/L to 5 mg/L. The primary cause of low summertime dissolved oxygen in the Keno Impoundment (including Lake Ewauna) is settling and decomposition of algae exported from Upper Klamath Lake (see Section 3.2.2.5). In the Hydroelectric Reach, the seasonal variability in dissolved oxygen concentrations in J.C. Boyle Reservoir is highly influenced by the adverse dissolved oxygen conditions in the upstream Keno Impoundment. Dissolved oxygen in hypolimnetic waters of Copco 1 and Iron Gate reservoirs reach minimum values near 0 mg/L during the summer (see Section 3.2.2.5).

Under the No Action/No Project Alternative, the ongoing Williamson River Delta Project and Agency Lake and Barnes Ranches Project may contribute to long-term improvements in seasonally low dissolved oxygen in Upper Klamath Lake. These resource management actions may decrease overall suspended sediment and nutrient inputs to

Upper Klamath Lake and downstream reaches. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation of TMDL water quality improvement measures focus on dissolved oxygen through reductions in water temperature and nutrient concentrations. The Upper Klamath Lake Drainage TMDL (see Section 3.2.2.4) include the following recommended measures for working toward achievement of TMDL targets for TP loading as the primary method of improving dissolved oxygen (and pH) conditions in Upper Klamath River along with Upper Klamath Lake and Agency lakes:

- Implementation of BMPs for improving dissolved oxygen in the Sprague River
- Reductions in phosphorus, nitrogen, and BOD loading from both point and nonpoint sources in the Upper Klamath River

Additionally, the Upper Klamath River and Lost River Sub-basins TMDLs require dissolved oxygen augmentation to J.C. Boyle Reservoir and several impoundments on the Lost River (the latter is not included in the area of analysis). The Lower Lost River pH and nutrient TMDLs were designed to ensure that California's numeric dissolved oxygen water quality standard would be attained. In California, one of the three TMDL load allocations assigned to the KHP is to create sufficient dissolved oxygen in Copco 1 and Iron Gate Reservoirs through a compliance lens, such that water temperature and dissolved oxygen conditions would be suitable for cold water fish during the critical summer period (see Section 3.2.2.4).

Full attainment of the measures in the Oregon and California TMDLs would result in waters meeting water quality standards; however, the timeframes for achieving dissolved oxygen (DO) allocations required under these TMDLs will depend on the measures taken to improve water quality conditions, especially reductions in nutrients. Based on Oregon numeric water quality standards, dissolved oxygen levels in the Upper Klamath Basin would need to meet natural conditions or attain 5.5 mg/L (year-round minimum for warm water aquatic life), 6.5 mg/L (year-round minimum for cool water aquatic life), 8.0 mg/L (year-round minimum for coldwater aquatic life), or 11.0 mg/L (January 1–April 15 minimum for spawning) (see Table 3.2-3). As with water temperature, the narrative Oregon standard stipulates that the natural conditions criterion supersedes the numeric criterion and is the standard for that water body (see Table 3.2-3). For California, dissolved oxygen would need to achieve 90 percent saturation based on natural receiving water temperatures during October–March and 85 percent saturation during April–September (see Table 3.2-4). The Klamath TMDL model (see Appendix D) indicates that under the No Action/No Project Alternative with full attainment of the TMDLs (similar to the T4BSRN scenario) dissolved oxygen in the riverine portions of the reach from Link River Dam to the Oregon-California state line would meet Oregon's 6.5 mg/L numeric objective for supporting the cool water aquatic life beneficial use (see Figure 3.2-16). Dissolved oxygen predicted levels would be similar to the modeled natural conditions baseline (TMDL T1BSR scenario) (NCRWQCB 2010a).

Klamath TMDL model results for riverine conditions at the Oregon-California state line indicate a similar pattern, whereby predicted dissolved oxygen concentrations meet the 6.5 mg/L objective year round and achieve the modeled natural conditions baseline during the warm summer and fall months (Figure 3.2-17). Under full TMDL compliant conditions, the California 85 percent saturation objective (based on natural receiving water temperatures) is met at state line under the No Action/No Project Alternative (Figure 3.2-17). Thus, full attainment of the Oregon and California TMDLs would eventually be beneficial for dissolved oxygen in the Hydroelectric Reach. Full attainment could require decades to achieve and it is highly dependent on improvements in dissolved oxygen in Upper Klamath Lake and the upstream reach from Link River Dam to J.C. Boyle Dam (particularly Keno Impoundment and Lake Ewauna).

Climate change is expected to cause a small anticipated decrease in dissolved oxygen due to general increases in water temperature in the Klamath Basin on the order of 2–3°C (3.6–5.4°F) over the period of analysis (i.e., 50 years) (Bartholow 2005; see also Section 3.2.4.3, Alternative 1: No Action/No Project Alternative: Water Temperature: Upper Klamath Basin). This would decrease the 100 percent saturation level for dissolved oxygen by an estimated 0.3–0.4 mg/L, using general assumptions for water temperature (20–24°C [68–75.2°F]), salinity (0 ppt) and elevation (1,433 m [4,700 ft]), where the elevation of Upper Klamath Lake is used as a simplifying assumption for the calculation. Climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Upper Klamath Basin. Alternately, increased levels of algal growth and photosynthesis anticipated under climate change (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections) may increase daytime dissolved oxygen concentrations during summer months. The magnitude of this increase is unknown.

**Existing seasonal dissolved oxygen levels in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly increase dissolved oxygen. Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would result in no change from existing conditions.**

#### Lower Klamath Basin

*Continued impoundment of water at the Four Facilities could result in long-term seasonal and daily variability in dissolved oxygen concentrations in the Klamath River downstream of Iron Gate Dam, such that levels do not meet California North Coast Basin Plan and Hoopa Valley Tribe water quality objectives and adversely affect beneficial uses.* Under existing conditions, dissolved oxygen in the Klamath River exhibits seasonal and daily variability immediately downstream of Iron Gate Reservoir with frequent violations of the California water quality objective (expressed as percent saturation, see Table 3.2-5) during late summer/early fall (July–September) (see Section 3.2.3.5). Dissolved oxygen levels generally recover with distance downstream, but they still exhibit occasional minimum values below objectives during late summer/early fall downstream of the confluence with the Trinity River (RM 40). The Hoopa Valley Tribe (8 mg/L) water quality objective for dissolved oxygen, which applies at ≈RM 45–46, is

also infrequently met during late summer/early fall months (see Section 3.2.3.5). Thus, dissolved oxygen conditions currently do not fully support designated beneficial uses COLD and WARM beneficial uses (see Table 3.2-4) in the Klamath River downstream of Iron Gate Dam.

Under the No Action/No Project Alternative, IM 3, Iron Gate Turbine Venting, as part of ongoing KHSa IM studies (see also Section 3.2.4.1), may be used to augment dissolved oxygen in the river for a short distance (approximately one-quarter mile) downstream of the dam prior to 2020 (see Section 3.2.3.1, Upper Klamath Basin – Dissolved Oxygen – Hydroelectric Reach). However, pilot studies to date have not indicated that turbine venting efforts would be a viable long-term solution for dissolved oxygen impairment from the reservoirs.

In the Lower Klamath Basin, the California Klamath River TMDLs include a specific focus on dissolved oxygen improvements. Full attainment of water quality improvement measures under the Oregon TMDLs would improve dissolved oxygen in the California portions of the Klamath River as well, particularly since California Klamath River TMDLs were developed based on compliance with water quality objectives at the Oregon-California state line. Specific dissolved oxygen allocations are assigned to the KHP and TN, TP, and CBOD allocations are assigned to the mainstem river and tributaries to support improvement toward dissolved oxygen targets (i.e., water quality objectives for dissolved oxygen). Specific monthly dissolved oxygen numeric targets are also assigned to the Copco and Iron Gate tailraces, based on percent saturation (see Section 3.2.2.4). General measures under the California Klamath River TMDLs associated with dissolved oxygen in the Klamath River include the following:

- A conditional waiver (developed by 2012) for discharges from agricultural activities (e.g., grazing, irrigated agriculture)
- Prohibiting the unauthorized discharge of waste that is in violation of water quality standards

The Shasta River TMDLs also address dissolved oxygen. Dissolved oxygen improvements in the Shasta River would be expected to improve concentrations in the Klamath River mainstem at or downstream of the confluence with the Shasta River (RM 176.7). Multiple water quality improvement measures in the Shasta River TMDL focus on dissolved oxygen (see Section 3.2.2.4).

Full attainment of the measures in the Oregon and California TMDLs would result in waters meeting water quality standards; however, the timeframes for achieving dissolved oxygen allocations and targets required under these TMDLs will depend on the measures taken to improve water quality conditions, especially reductions in nutrients in upstream reaches. The Oregon and California with-dam TMDL scenario (T4BSRN - see Appendix D) was run in order to quantify the impacts of the dams on water quality and to determine appropriate allocations and targets. The Klamath with-dam TMDL modeling scenario indicates that under the No Action/No Project Alternative (similar to the TMDL T4BSRN scenario), dissolved oxygen concentrations downstream of Iron Gate Dam to the Shasta



River (RM 176.7), without additional mitigation, would not meet the North Coast Basin Plan water quality objective of 85 percent saturation (see Tables 3.2-4 and 3.2-5) during July–September and from the Shasta River to approximately the Scott River (RM 143) from September–November (see Figures 3.2-19 and 3.2-20). The inability to achieve the water quality objective of 85% saturation under TMDL compliance conditions from Iron Gate Dam to the Shasta River is due to the release of low dissolved oxygen water from the hypolimnion of the reservoir. This result indicates that while full attainment of the California Klamath TMDLs would result in dramatic improvements in dissolved oxygen both upstream and downstream of Iron Gate Dam, release of low dissolved oxygen water from the hypolimnion (i.e., the bottom layer within stratified reservoir) inhibits compliance from the Iron Gate tailrace to the Scott River with the dams in place. The TMDL does include dissolved oxygen targets for the tailrace that meet water quality objectives. It is possible that there are management practices that PacifiCorp could use to meet the TMDL dissolved oxygen targets. However, these practices have not been demonstrated to date and the NCRWQCB could not make presumptions regarding what these practices might be. Therefore, these enhancements were not included in the with-dams TMDL modeling scenario. Therefore, the TMDL Action Plan includes a requirement for PacifiCorp to develop a Reservoir Management Plan that specifically addresses water temperature and dissolved oxygen improvements that would allow the KHP facilities and downstream reaches to meet water quality objectives (NCRWQCB 2010a).

Farther downstream with full attainment of TMDL allocations, predicted dissolved oxygen concentrations would remain at or above 85 percent saturation, meeting the North Coast Region Basin Plan water quality objective from Seiad Valley (RM 129.4) to the Klamath Estuary. Despite this, predicted dissolved oxygen would infrequently meet the Hoopa Valley Tribe numeric dissolved oxygen objective of 8 mg/L (see Table 3.2-6), which applies at ≈RM45–46, because warm water temperatures during July–October would decrease the saturation level of oxygen in the water column to less than 8 mg/L (see Figure 3.2-20 and 3.2-21). However, Hoopa Valley Tribe has a natural conditions clause requiring dissolved oxygen to achieve 90% saturation if numeric values are not met; predicted dissolved oxygen concentrations would meet this natural condition clause. Throughout the lower Klamath River, daily fluctuations in dissolved oxygen during July–October would occur due to colonization of periphyton mats in the river and the associated photosynthetic swings in oxygen production.

As described for the Upper Klamath Basin, climate change would decrease the 100 percent saturation level for dissolved oxygen in the lower basin by increasing water temperatures. In the lower basin, this would result in an estimated 0.3–0.5 mg/L decrease in dissolved oxygen, using general assumptions for water temperature (20–24°C [68–75.2°F]), salinity (0 ppt) and elevation at sea level as a simplifying assumption for the calculation. The small anticipated decreases in dissolved oxygen due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Lower Klamath Basin. As with the upper basin, increased levels of algal growth and photosynthesis anticipated under climate change (Barr et al. 2010) (see Section 3.10.3.1,

Existing Conditions – Climate Change Projections) may increase daytime dissolved oxygen concentrations during summer months. The magnitude of this increase is unknown.

**Existing seasonal dissolved oxygen levels immediately downstream of Iron Gate Dam are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly increase dissolved oxygen, although seasonal concentrations from Iron Gate Dam to the Shasta River would remain adverse. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### **3.2.4.3.1.5 pH**

##### Upper Klamath Basin

*Continued impoundment of water at the Four Facilities could result in long-term seasonal and daily variability in pH in the Hydroelectric Reach.* Under existing conditions, pH values in the Hydroelectric Reach range from just above neutral to greater than 9, with large (0.5–1.5 pH units) daily fluctuations occurring in reservoir surface waters during periods of intense algal blooms. During these periods, pH levels infrequently meet applicable ODEQ and California North Coast Basin Plan water quality objectives (see Table 3.2-3 and Table 3.2-4), and adversely affect beneficial uses.

Several ongoing resource management actions represent reasonably foreseeable actions within the period of analysis that may affect pH. Although initially resulting in increased nutrient release, the ongoing Williamson River Delta Project and Wood River Wetland Restoration are expected to eventually reduce nutrient inputs to Upper Klamath Lake which may decrease algal bloom populations and rates of photosynthesis, correspondingly decreasing observed pH maximums in the lake and its tributaries. Additional resource management actions such as floodplain rehabilitation, riparian vegetation planting, and purchase of conservation easements/land related to nutrients are currently ongoing in the Upper Klamath Basin (see Section 2.3.1) and are expected to continue to improve long-term pH in the Upper Klamath Lake. This may indirectly decrease pH maximums in the Hydroelectric Reach. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation of TMDL measures focused on pH in the Upper Klamath Lake Drainage TMDL and WQMP and those in the draft Upper Klamath River and Lost River Sub-basins TMDL and WQMP (see Section 3.2.2.4) include decreased loading of total phosphorous as the primary method for decreasing pH in Upper Klamath and Agency lakes and in the Sprague River. While the California Klamath River TMDLs do not include specific allocations or targets for pH, load allocations and targets for TN and TP assigned to the KHP are designed to limit algal photosynthesis, which will decrease maximum pH levels and daily variability in the Hydroelectric Reach. The California Lower Lost River TMDLs also include pH allocations.

The Oregon and California TMDLs in the Upper Klamath Basin are designed to achieve water quality objectives; however, the timeframes for achieving pH objectives will depend on the measures taken to improve water quality conditions, especially reductions in nutrients. To consistently support beneficial uses, pH cannot be below 6.5 units or above 9.0 units in Oregon (see Table 3.2-3) and cannot be depressed below 7.0 units nor raised above 8.5 units in California upstream or downstream of Iron Gate Dam (see Table 3.2-4). The pH in the reach from Link River Dam to just upstream of J.C. Boyle Reservoir, and to the Oregon-California state line in the Hydroelectric Reach, would meet water quality objectives for Oregon. Similarly, in California from the state line to Iron Gate Dam, pH is expected to trend toward achievement of water quality objectives given full attainment of the TMDLs within the period of analysis (NCRWQCB 2010a). Full attainment could require decades to achieve.

Anticipated climate change effects on pH include earlier, longer, and more intense algal blooms (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections), which may increase pH maximums due to higher overall rates of photosynthesis during summer months. The anticipated increases in pH due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Upper Klamath Basin; however, the magnitude of the opposition is unknown.

**Existing seasonal fluctuations in pH occurring during periods of intense algal blooms in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve pH. Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would result in no change from existing conditions.**

#### Lower Klamath Basin

*Continued impoundment of water at the Four Facilities could result in long-term seasonal and daily variability in pH in the Klamath River downstream of Iron Gate Dam.* Under existing conditions, pH during late-summer and early-fall months (August–September) in the Klamath River downstream of Iron Gate Dam ranges from just above neutral to greater than 9, with large (0.5–1.5 pH units) daily fluctuations occurring in the lower river during periods of high photosynthesis (see Section 3.2.3.6). In California, to consistently support beneficial uses in the Klamath, pH cannot be depressed below 7.0 units nor raised above 8.5 units (see Table 3.2-4).

While the California Klamath River TMDLs do not include specific allocations or targets for pH, load allocations and targets for TN and TP assigned to the KHP are designed to limit algal photosynthesis, which will decrease maximum pH levels and daily variability in the Klamath River downstream of Iron Gate Dam.

The timeframes for achieving pH objectives will depend on the measures taken to improve water quality conditions, especially reductions in nutrients. The Klamath TMDL model (see Appendix D) indicates that under the No Action/No Project

Alternative (similar to TMDL T4BSRN scenario) pH in the reach from Seiad Valley (RM 129.4) to downstream of the mainstem confluence with Indian Creek (RM 108) would meet water quality objectives. While model results indicate that daily maximum values in some stretches of the Klamath River downstream of Iron Gate Dam may not meet the Basin Plan water quality objective of 8.5 pH units (see Table 3.2-4), within the resolution of the Klamath TMDL model these potentially occasional exceedances of the pH objective would not be expected to substantially adversely affect beneficial uses. The Hoopa Valley Tribe water quality objective for pH (7.0–8.5) (see Table 3.2-6) is met at the location that it is applicable ( $\approx$ RM 45–6) (NCRWQCB 2010a). Therefore, pH under the No Action/No Project Alternative would meet pH water quality objectives for California within the period of analysis due to full attainment of the California TMDLs (NCRWQCB 2010a). It is anticipated that full attainment of the TMDLs would require decades to achieve.

Anticipated climate change effects on pH include earlier, longer, and more intense algal blooms (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections), which may increase pH maximums due to higher overall rates of photosynthesis during summer months. The anticipated increases in pH due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Lower Klamath Basin; however, the magnitude of the opposition is unknown.

**Existing seasonal fluctuations in pH downstream of Iron Gate Dam, which occur during periods of intense algal blooms in the upstream reservoirs, are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve pH. Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would result in no change from existing conditions.**

#### **3.2.4.3.1.6 Chlorophyll-a and Algal Toxins**

##### **Upper Klamath Basin**

*Continued impoundment of water at the Four Facilities could support long-term growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa*, resulting in high seasonal concentrations of chlorophyll-a and algal toxins in the Hydroelectric Reach.* Under existing conditions, chlorophyll-a samples during summer and fall in Upper Klamath Lake and the reservoirs at the Four Facilities exhibit annual mean values  $>10$   $\mu\text{g/L}$  (measured May through October) with the highest values ( $> 100$   $\text{mg/L}$ ) occurring in surface waters during late summer periods of intense algal blooms (see Section 3.2.3.1). High ( $>8$   $\mu\text{g/L}$ ) seasonal levels of algal toxins (microcystin) are linked to intense blue-green algae blooms and exceed applicable ODEQ water quality objectives for toxic substances (see Table 3.2-3) and the North Coast Basin Plan water quality objectives for toxicity (see Table 3.2-4). This adversely affects beneficial uses, particularly the human health water contact recreational use (REC-1) and the cultural use (CUL).

As with other water quality parameters analyzed in this EIS/EIR (i.e., water temperature, sediment, nutrients, dissolved oxygen, pH), several ongoing resource management actions represent reasonably foreseeable actions within the period of analysis that may affect algal toxins and chlorophyll-*a* concentrations in the Upper Klamath Basin. The ongoing Williamson River Delta Project and Wood River Wetland Restoration are intended to eventually reduce nutrient inputs to Upper Klamath Lake, which may help decrease the incidence of toxic cyanobacterial algal blooms and high chlorophyll-*a* levels and algal toxins in Upper Klamath Lake and reduce those transported downstream to the Hydroelectric Reach. Additional resource management actions such as floodplain rehabilitation, riparian vegetation planting, and purchase of conservation easements/land related to nutrients are ongoing in the Upper Klamath Basin (see Section 2.3.1) and are expected to continue to decrease long-term levels of algal toxins and chlorophyll-*a* in Upper Klamath Lake. This may slightly decrease concentrations in the Hydroelectric Reach. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation of measures related to chlorophyll-*a* and algal toxins in the Upper Klamath Lake Drainage TMDL and WQMP and those in the Upper Klamath River and Lost River Sub-basins TMDL and WQMP (see Section 3.2.2.4) include decreased loading of TP as the primary method for decreasing the magnitude of algal productivity (blooms) affecting the high rates of photosynthesis and the related water quality problems (e.g., pH, dissolved oxygen) in the Sprague River, Upper Klamath and Agency lakes, and the Keno Reach. Decreases in upstream algal blooms would result in corresponding decreases in chlorophyll-*a* concentrations and, for toxin-producing algal species, levels of microcystin in the Hydroelectric Reach.

Additionally, the Oregon and California TMDLs include specific load allocations for TN and TP upstream of the Klamath Hydropower Facilities (see Section 3.2.2.4), which are intended to eventually limit the extensive algal blooms in Copco 1 and Iron Gate Reservoirs and thus decrease chlorophyll-*a* and algal toxin levels toward the TMDL targets of 10 µg/L chlorophyll-*a* (growing season average), *M. aeruginosa* cell density ≤20,000 cells/L, and microcystin toxin <4 µg/L (see Table 3.2-10). Full attainment of the measures in the Oregon and California TMDLs would result in waters meeting water quality standards; however, the timeframes for achieving water quality objectives with respect to algal toxins and chlorophyll-*a* will depend on the measures taken to improve water quality conditions. This would require decades to achieve and it is highly dependent on improvements in nutrients in the upstream reach from Link River Dam to J.C. Boyle Dam (particularly Keno Impoundment including Lake Ewauna).

Anticipated climate change effects include earlier, longer, and more intense algal blooms (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections), which may increase algal toxin and chlorophyll-*a* concentrations due to higher overall rates of photosynthesis during summer months. The anticipated effects of climate change would also occur over a timescale of decades and may slightly offset

improvements expected from successful TMDL implementation throughout the Upper Klamath Basin.

**Existing seasonal blooms of toxin-producing nuisance algal species and corresponding levels of chlorophyll-*a* and algal toxins in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease chlorophyll-*a* and algal toxins. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### Lower Klamath Basin

*Continued impoundment of water at the Four Facilities could support long-term growth conditions for toxin-producing nuisance algal species such as M. aeruginosa, resulting in high seasonal concentrations of chlorophyll-*a* and algal toxins (e.g., microcystin) transported into the Klamath River from downstream of Iron Gate Dam to the Klamath Estuary, and potentially the marine nearshore environment.* Under existing conditions, chlorophyll-*a* concentrations during summer through fall in the Klamath River downstream of Iron Gate Dam are lower than those in Upper Klamath Lake and the KHP reservoirs due to interception of algae by the KHP dams. However, concentrations are variable by location and increase as a result of periodic seasonal (i.e., summer, fall) in-reservoir algal blooms that are transported into the lower river (see Section 3.2.3.7). These algal blooms can be toxic and can exceed numeric thresholds for microcystin (8 µg/L) posing a human health risk and substantially adversely affecting recreational beneficial uses, particularly water contact (REC-1) and CUL uses. Although the CUL beneficial use has only been approved for the Hoopa Valley Tribe thus far (see Table 3.2-2), known or perceived risks of exposure to degraded water quality conditions due to algal toxins during ceremonial bathing and traditional cultural activities have resulted in impairment of this beneficial use for the Karuk Tribe as well (see also Section 3.12.3.3). Additionally, Hoopa Valley Tribe water quality objectives for toxigenic cyanobacteria species and cyanobacterial scums are not consistently met during summer months (see Section 3.2.3.7 and Appendix C for more detail). Microcystin can also bioaccumulate in aquatic biota, including filter feeders and fish. A discussion of algal toxins as related to fish health is presented in Section 3.3.3.2, Physical Habitat Descriptions - Water Quality - Algal Toxins. Lastly, there is emerging evidence that cyanotoxins flushing from coastal rivers into Monterey Bay, California were responsible for numerous sea otter deaths in 2007 (Miller et al. 2010). While it is not known if conditions in Monterey Bay are similar to those in the Klamath River marine nearshore environment, there may be potential for microcystin to adversely impact marine organisms under the No Action/No Project Alternative.

The California Klamath River TMDLs include specific load allocations for TN and TP upstream of the Four Facilities to offset the reduced nutrient assimilative capacity in the reservoirs (see Section 3.2.2.4, Klamath River TMDLs); the decreased nutrient loads would limit algal growth and decrease chlorophyll-*a* and algal toxin levels in the KHP reservoirs toward the TMDL targets of 10 µg/L chlorophyll-*a* (growing season average), *M. aeruginosa* cell density 20,000 cells/L, and microcystin toxin <4 µg/L (NCRWQCB

2010a). This would subsequently decrease levels of chlorophyll-*a* and algal toxins transported into the Lower Klamath River, the Klamath Estuary, and the marine nearshore environment. This would require decades to achieve and it is highly dependent on upstream nutrient improvements.

As with the Upper Klamath Basin, anticipated effects of climate change on chlorophyll-*a* and algal toxins would occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Lower Klamath Basin; however, the magnitude of the opposition is unknown.

**Existing transport of seasonal blooms of toxin-producing nuisance algal species, chlorophyll-*a*, and algal toxins into the Klamath River from downstream of Iron Gate Dam to the Klamath Estuary are adverse. Transport to the marine nearshore environment is potentially adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease chlorophyll-*a* and algal toxins. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

#### **3.2.4.3.1.7 Inorganic and Organic Contaminants**

##### Upper Klamath Basin

##### *Freshwater Aquatic Life Toxicity and/or Bioaccumulation*

Effects of the No Action/No Project Alternative on potential inorganic and organic contaminants in Upper Klamath Lake and its major tributaries cannot be assessed directly due to a lack of information for these parameters (see Section 3.2.3.8, Upper Klamath Lake – Inorganic and Organic Contaminants). However, under the No Action/No Project Alternative, ongoing resource management actions (i.e., Williamson River Delta Project, Agency Lake and Barnes Ranches Project) may reduce transport of inorganic and organic contaminants into Upper Klamath Lake and downstream reaches. While Oregon and California TMDLs do not address inorganic and organic contaminants, under the No Action/No Project Alternative TMDL implementation may indirectly limit transport of inorganic and organic contaminants through mechanisms expected to reduce suspended sediments and nutrients.

Low levels of organic and inorganic contaminants have been identified in the sediment deposits trapped behind the dams in the Hydroelectric Reach (see Section 3.2.3.8). Benthic uptake and subsequent transfer through the food web is one potential pathway of contaminant exposure for aquatic organisms in the Hydroelectric Reach; exposure to water column contaminants is also a possible pathway. Sediment contaminants influenced by pH or dissolved oxygen, such as methylmercury, may flux into the water column via the low redox conditions supported by reservoir stratification and seasonal anoxia. Human exposure to methylmercury, inorganic contaminants (e.g., arsenic), and organic contaminants (e.g., pesticides, PCBs, PAHs) associated with reservoir sediments may occur through consumption of contaminated reservoir fish or shellfish. Potential effects of the No Action/No Project Alternative are further discussed below using available water column, sediment, and aquatic biota contaminant data.

*Continued impoundment of water at the Four Facilities and associated interception and retention of sediments behind the dams could result in long-term low-level exposure to inorganic and organic contaminants for freshwater aquatic species in the Hydroelectric Reach.*

Water Column Contaminants. Water quality data collected during in Copco 1 and Iron Gate reservoirs during 2001–2005 under the SWAMP indicate that concentrations of numerous inorganic compounds (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) and organic compounds (i.e., pesticides, PCBs, phenols) were in compliance with water quality objectives (NCRWQCB 2008; see Section 3.2.3.1 and Appendix C, Section C.7.1.1 for more detail).

Sediment Contaminants. Two studies provide data for the evaluation of sediment toxicity and bioaccumulation potential under the No Action/No Project Alternative:

- Sediment chemistry data collected during 2004–2005 from 26 cores in J.C. Boyle, Copco 1, and Iron Gate Reservoirs (Shannon & Wilson, Inc. 2006). The 2004–2005 sediment chemistry data indicate generally low levels of metals, pesticides, chlorinated acid herbicides, PCBs, VOCs, SVOCs, cyanide, and dioxins (Shannon & Wilson, Inc. 2006; see Section 3.2.3.1).
- Sediment chemistry and toxicity data collected during 2009–2010 as part of the Secretarial Determination process, including samples from J.C. Boyle, Copco 1, and Iron Gate Reservoirs, and the Klamath Estuary (Department of the Interior 2010a and exposure “Scenario 1” in CDM [2011]). Based on comparison to appropriate freshwater sediment screening levels (see Section 3.2.3.8 and Appendix C for more detail), no exceedances of detected chemicals were found in sediment samples, indicating a low risk of toxicity to freshwater sediment-dwelling organisms in the Hydroelectric Reach under the No Action/No Project Alternative. Based on additional lines of evidence (i.e., toxicity tests, calculation of TEQs), there does not appear to be a substantial sediment toxicity concern for national benchmark benthic indicator species from Copco 1 and Iron Gate Reservoir under the No Action/No Project Alternative. The exception to this occurred in a single sample from J.C. Boyle Reservoir, where survival of the benthic amphipod *Hyalella azteca* indicated a moderate potential for toxicity. TEQs for dioxin, furan, and dioxin-like PCBs in reservoir and estuary sediment samples were within the range of local background values and suggest a limited potential for adverse effects for fish exposed to reservoir sediments under the No Action/No Project Alternative (CDM 2011). Lastly, sediment samples were also evaluated for levels of known bioaccumulative compounds; ODEQ bioaccumulation sediment screening values were not exceeded in J.C. Boyle Reservoir sediments, with the exception of a small number of samples for DDTs (i.e., 4,4'-DDT, 4,4'-DDD, 4,4'-DDE) (CDM 2011).



Contaminants in Aquatic Biota. The potential for bioaccumulation under the No Action/No Project Alternative can also be evaluated using fish tissue concentrations. Two studies provide data for the evaluation of bioaccumulation potential in freshwater fish:

- PacifiCorp (2004c) conducted a screening-level analysis looking at metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc), organochlorine pesticides, and PCBs in the Hydroelectric Reach and Upper Klamath Lake. The PacifiCorp data suggest that, with two exceptions, fish in the KHP reservoirs do not appear to be exposed to levels of contaminants that may adversely affect beneficial uses or that are toxic or detrimental to aquatic life. The exceptions include exceedances of the total mercury wildlife screening level (0.00227 ug/g) for all tissue samples in Keno, J.C. Boyle, Copco 1, and Iron Gate Reservoirs (see Appendix C for more detail), suggesting that localized mercury methylation may be occurring during periods of stratification and anoxia in the reservoirs (see Table 3.2-5). Another exception is that exceedances of recommended wildlife screening levels for total DDTs based on p,p'-DDE found in fish tissue samples from Upper Klamath Lake, the Keno Impoundment, J.C. Boyle Reservoir, and Copco 1 Reservoir (see Section 3.2.3.1, Inorganic and Organic Contaminants – Hydroelectric Reach), may suggest a possible broader-scale bioaccumulation effect (see Appendix C, Table C-7).
- Results from the 2009-2010 Secretarial Determination fish tissue sampling (exposure “Scenario 1” in CDM [2011]) indicate that mercury is present in fish tissue at levels with potential to cause minor or limited adverse effects to fish; multiple other chemicals are not present at such levels, or they are present but do not possess tissue-based TRVs for comparison (see Section 3.2.3.8 and Appendix C for more detail). Fish tissue results were also below dioxin, furan, and dioxin-like PCB TEQs, indicating no adverse effect (CDM 2011). Combined with the sediment contaminant data (see above), inorganic and organic contaminants are present in reservoir sediments at levels that have the potential to cause minor or limited adverse effects (i.e., toxicity or bioaccumulation) to freshwater aquatic species (Figure 3.2-2).

Exposure Scenario		Freshwater biota	Marine biota	Terrestrial biota	Humans
Scenario 1 (No Action Alternative)	Long-term exposure to reservoir sediments	●			●
Scenario 2 (Proposed Action)	Short-term exposure to sediments flushed downstream	●	●		
Scenario 3 (Proposed Action)	Long-term exposure to exposed reservoir terrace and or river bank deposits			● <sup>(1)</sup>	● <sup>(1)</sup>
Scenario 4 (Proposed Action)	Long-term exposure to river bed deposits	●			●
Scenario 5 (Proposed Action)	Long-term exposure to marine / near shore deposits		●		

●	No adverse effects based on lines of evidence
●	One or more chemicals present, but at levels unlikely to cause adverse effects based on the lines of evidence
●	One or more chemicals present at levels with potential to cause minor or limited adverse effects based on the lines of evidence
●	At least one chemical detected at a level with potential for significant adverse effects based on the lines of evidence
	This exposure pathway is incomplete or unimportant for this receptor group

**Figure 3.2-2. Summary of Anticipated Effects of Inorganic and Organic Contaminants in Klamath Reservoir and Estuary Sediments Under the No Action/No Project Alternative and the Proposed Action. This does not include an evaluation of the physical effects (e.g., dissolved oxygen, suspended sediment). (1): Qualitative evaluation conducted for this exposure scenario. Source: CDM 2011.**

**Existing inorganic and organic contaminant data characterizing reservoir sediments at the Four Facilities indicate that a relatively small number of chemicals (i.e., mercury, DDTs, and possibly dioxin-like chemicals) are present in reservoir sediments at levels that have the potential to cause minor or limited adverse effects (i.e., toxicity or bioaccumulation) to freshwater aquatic species in the Hydroelectric Reach. Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would result in no change from existing conditions.**

*Continued impoundment of water at the Four Facilities and associated interception and retention of sediments behind the dams could result in long-term low-level exposure to inorganic and organic contaminants in the Hydroelectric Reach for humans through the consumption of resident fish tissue. Human health exposure to inorganic or organic chemicals in reservoir sediments under the No Action/No Project Alternative is through consumption of resident fish. Under the No Action/No Project Alternative, direct human exposure to sediments is not considered a reasonable exposure pathway. Three studies provide data for the evaluation of human health exposure through consumption of resident fish:*

- Results from California SWAMP fish tissue sampling in Copco 1 and Iron Gate Reservoirs indicate mercury tissue concentrations of 0.31 and 0.33 ng/g wet weight, respectively (Davis et al. 2010). These data are greater than the advisory tissue levels for 3 and 2 servings per week (70 and 150 ng/g wet weight, respectively) and the fish contaminant goal (220 ng/g wet weight) (see Section 3.2.3.1), suggesting low-level bioaccumulation potential in the two largest KHP reservoirs.
- PacifiCorp (2004c) reported that, in general, fish in the reservoirs at the Four Facilities are not exposed to levels of contaminants that may adversely affect human health via fish consumption. Exceptions to this include arsenic and total PCBs, which may equal or exceed the toxicity screening level for subsistence fishers (see Section 3.2.3.1; PacifiCorp 2004c). Additionally, a subsequent review of the PacifiCorp data and conversion to wet weight values found that mercury levels exceeded the screening level for subsistence fishers (0.049 ug/g) for samples from Keno, J.C. Boyle, Copco 1, and Iron Gate Reservoirs, and exceeded the screening level for recreational fishers (0.4 ug/g) for samples from samples from Copco 1 and Iron Gate Reservoirs (see Appendix C for more detail).
- Results from the 2010 Secretarial Determination fish tissue sampling indicate that a relatively small number of chemicals are present in fish tissue at levels with potential to cause minor or limited adverse effects to humans through fish consumption (Figure 3.2-2). These include arsenic, total PCBs, and dioxins in yellow perch at J.C. Boyle, Copco 1, and Iron Gate reservoirs (CDM 2011). In bullhead, the same chemicals are present, with the addition of mercury for Copco 1 Reservoir (see Section 3.2.3.8 and Appendix C for more details).

In summary, existing fish tissue, bioassay, and sediment chemistry data indicate that continued retention of sediments behind the KHP dams under the No Action/No Project Alternative may result in concentrations of inorganic and organic contaminants at levels that adversely affect beneficial uses or are toxic to humans in the Hydroelectric Reach. This includes possible exposure to low-level bioaccumulation of arsenic (which may be naturally elevated in the Upper Klamath Basin [see Section 3.2.2.8, Inorganic and Organic Contaminants]) and mercury in fish residing in the lacustrine environment of the Keno Impoundment (including Lake Ewauna) and J.C. Boyle, Iron Gate, and Copco 1 Reservoirs.

**Existing inorganic and organic contaminant data characterizing fish tissue in the reservoirs at the Four Facilities indicate that a relatively small number of chemicals (i.e., mercury, arsenic, total PCBs, and dioxins) are present at levels that have the potential to cause minor or limited adverse effects to humans through fish consumption in the Hydroelectric Reach. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.**

### Lower Klamath Basin

With the possible exception of compounds (i.e., mercury) that can be released (exported) from reservoir bottom waters under seasonally anoxic conditions, continued impoundment of water at the Four Facilities is not anticipated to result in increased exposure to inorganic and organic contaminants for freshwater aquatic species in the Klamath River downstream of Iron Gate Dam. This is because contaminants that may be present in reservoir sediments at the Four Facilities would remain in place under the No Action/No Project Alternative. There is currently insufficient information to assess whether the No Action/No Project Alternative would expose downstream aquatic biota to methylmercury released from bottom waters. Bioaccumulation of algal toxins (i.e., microcystin) has been documented in fish and mussel tissue in the Klamath River downstream of Iron Gate Dam (Kann et al. 2010) and is discussed further in Section 3.3, Aquatic Resources. Potential for the Proposed Action and alternatives to affect production and toxicity of algal toxins is discussed in Section 3.4, Algae.

#### **3.2.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)**

The Full Facilities Removal of Four Dams (Proposed Action) is the removal of four major dams in the Klamath Hydroelectric Project (J.C. Boyle, Copco 1, Copco 2, and Iron Gate) along with the ancillary facilities of each installation in a 20-month period which includes an 8-month period of site preparation and partial drawdown at Copco 1 and a 12-month period for full drawdown and removal of facilities. This includes the entire dam, the powerhouses, spillways, and other infrastructure associated with the power generating facilities, as well as the transfer of the Keno Dam facilities to the DOI and the implementation of the KBRA. Removal of the Four Facilities would not affect water quality in the following reaches in the Upper Klamath Basin: Wood, Williamson, and Sprague Rivers, Upper Klamath Lake, and Link River to the upstream end of J.C. Boyle Reservoir. In the Hydroelectric Reach of the Upper Klamath Basin, removal of the Four Facilities would result in the release of sediments currently trapped behind the dams. This release would have short-term (<2 years following dam removal) effects on suspended sediments, dissolved oxygen, nutrients, and inorganic and organic contaminant concentrations in the Klamath River. Under the Proposed Action, interception and retention of sediments behind the dams at the Four Facilities would no longer occur; this would have long-term (2–50 years following dam removal) effects on suspended sediments. Additionally, elimination of the lacustrine environment of the reservoirs under the Proposed Action would have long-term effects on water temperature, dissolved oxygen, nutrients, pH, algal toxins and chlorophyll-*a* in the river. The following sections provide detail regarding the anticipated effects. KBRA under the Proposed Action is addressed at a programmatic level in the last subsection of the Proposed Action.

#### **3.2.4.3.2.1 Water Temperature**

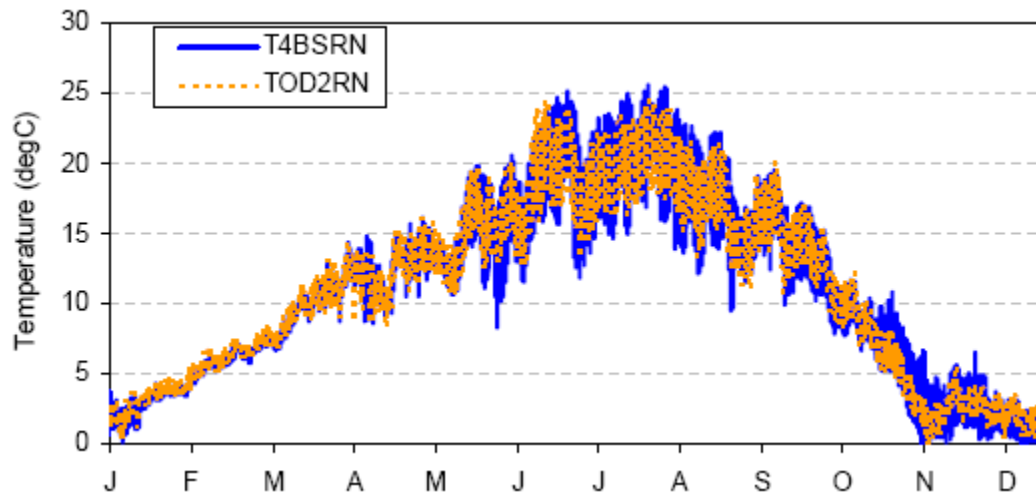
##### Upper Klamath Basin

*Removal of the Four Facilities under the Proposed Action and elimination of hydropower peaking operations at J.C. Boyle Powerhouse could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) alterations in daily water temperatures and fluctuations in the J.C. Boyle bypass and peaking reaches. Klamath TMDL model (see Appendix D) results indicate that under the*

Proposed Action (similar to the TMDL TOD2RN scenario, which includes Oregon TMDL allocations), water temperatures in the Hydroelectric Reach immediately downstream of J.C. Boyle Dam would be similar to those under the No Action/No Project Alternative, but there would be relatively *higher* daily fluctuations during June through September (similar to the TMDL T4BSRN scenario) due to the absence of the thermal mass in J.C. Boyle Reservoir, which tends to moderate daily temperature fluctuations immediately downstream of the dam under existing conditions (NCRWQCB 2010a). Higher daily fluctuations would also occur in the J.C. Boyle bypass reach because it would no longer be dominated by cold groundwater inputs at a relatively constant temperature of 11–12°C (Kirk et al. 2010, Asarian and Kann 2006a). Water temperatures in this short river reach would increase during summer months, moving it away from support of core coldwater habitat; however, areas adjacent to the coldwater springs in the bypass reach would continue to serve as thermal refugia for aquatic species because the springs themselves would not be affected by the Proposed Action. In the J.C. Boyle peaking reach model results indicate that water temperatures under the Proposed Action would be slightly lower (0.5–1°C [0.9–1.8°F]) than those predicted under the No Action/No Project and would exhibit *lower* daily fluctuation during June through September (NCRWQCB 2010a, Asarian and Kann 2006a). At these locations the relative difference in daily water temperature fluctuations between the Proposed Action and the No Action/No Project Alternative is due to the elimination of peaking operations and the associated large daily temperature swings.

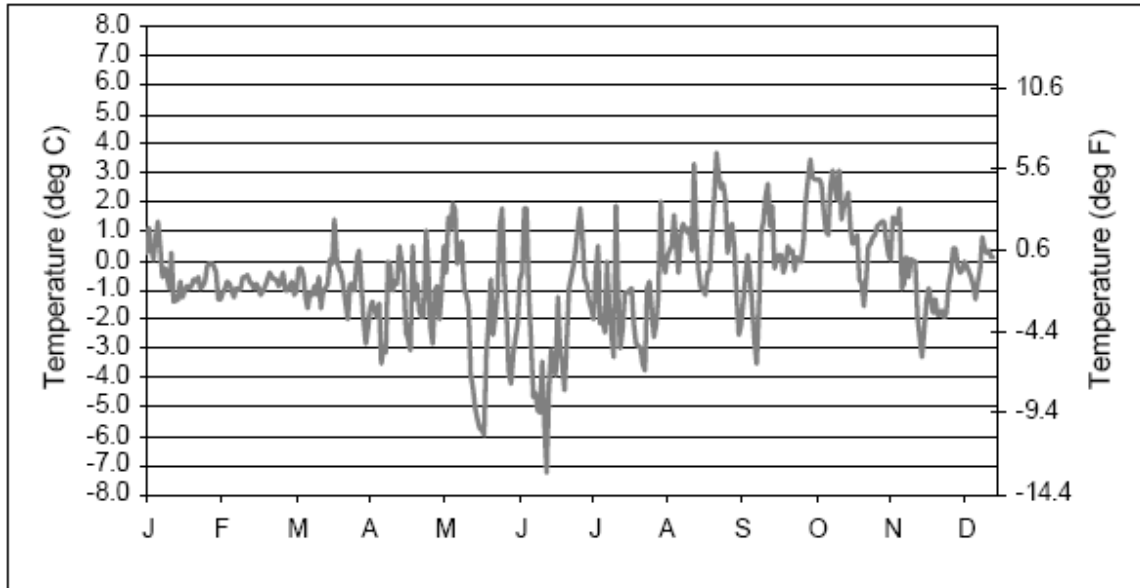
**Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in summer/fall water temperatures and daily fluctuations in the J.C. Boyle bypass reach due to the elimination of hydropower peaking operations would be a significant impact. Slight decreases in long-term summer/fall water temperatures and less daily fluctuation in the J.C. Boyle peaking reach would be beneficial.**

*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in spring water temperatures and decreases in late summer/fall water temperatures in the Hydroelectric Reach downstream of Copco 1 Reservoir.* In the Klamath River downstream of the J.C. Boyle bypass and peaking reaches, TMDL model results indicate that water temperatures under the Proposed Action would be slightly lower (0.5–1°C [0.9–1.8°F]) than those predicted under the No Action/No Project and would exhibit *lower* daily fluctuation during June through September (NCRWQCB 2010a, Asarian and Kann 2006a; Figure 3.2-3). Overall, the TMDL model results indicate that June through October riverine water temperatures from J.C. Boyle Reservoir to the Oregon-California state line would meet the Oregon narrative natural conditions criterion that supersedes the numeric objective (i.e., 16°C [60.8°F], see Table 3.2-3) for support of core coldwater habitat.



**Figure 3.2-3. Predicted Water Temperature at the California-Oregon State Line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**

In the California portion of the Hydroelectric Reach, the TMDL model indicates that removal of the Four Facilities under the Proposed Action would eliminate the seasonal temperature shift caused by the Four Facilities in the Hydroelectric Reach such that spring water temperatures would increase and late summer/fall temperatures would decrease. Just downstream of Copco 1 and Copco 2 Reservoirs ( $\approx$ RM 198), this would increase daily maximum temperatures that are currently up to  $7^{\circ}\text{C}$  ( $13^{\circ}\text{F}$ ) lower than modeled natural conditions in spring (May and June) and decrease temperatures that are up to roughly  $4^{\circ}\text{C}$  ( $7^{\circ}\text{F}$ ) greater than modeled natural conditions in late summer/fall (August through October), due to the presence of the reservoirs (Figure 3.2-4) (NCRWQCB 2010a). Water temperature modeling conducted for the Klamath Dam Removal Secretarial Determination Studies provides generally similar results, with RBM10 model results showing a projected shift in the annual temperature cycle that would slightly increase river temperatures in the spring, and decrease temperatures in the late summer/fall in the Hydroelectric Reach under the Proposed Action (Perry et al. 2011). Further discussion of RBM10 results is presented below for the Lower Klamath Basin.



**Figure 3.2-4. Estimated Changes in Daily Maximum Klamath River Water Temperatures at ≈RM 198 due to the Presence of Copco 1 and 2 Reservoirs for the 2000 Calendar Year. Positive Values Represent an Increase above Modeled Natural Conditions. Source: NCRWQCB 2010a.**

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020 (i.e., prior to thermal stratification in the reservoirs), the aforementioned water temperature effects of the Proposed Action in the Hydroelectric Reach would occur, either partially or fully, within the first 1 to 2 years following dam removal and would, therefore, also be short-term effects.

The Klamath TMDL model does not address the potential long-term effects of global climate change on water temperatures in the Klamath Basin (Appendix D). As described for the No Action/No Project Alternative, climate change is expected to increase summer and fall water temperatures in the Klamath Basin on the order of 1–3°C (1.8–5.4°F) (Bartholow 2005, Perry et al. 2011). The Proposed Action would decrease long-term late summer/fall water temperatures and would therefore increase the likelihood that beneficial uses would be supported under climate change.

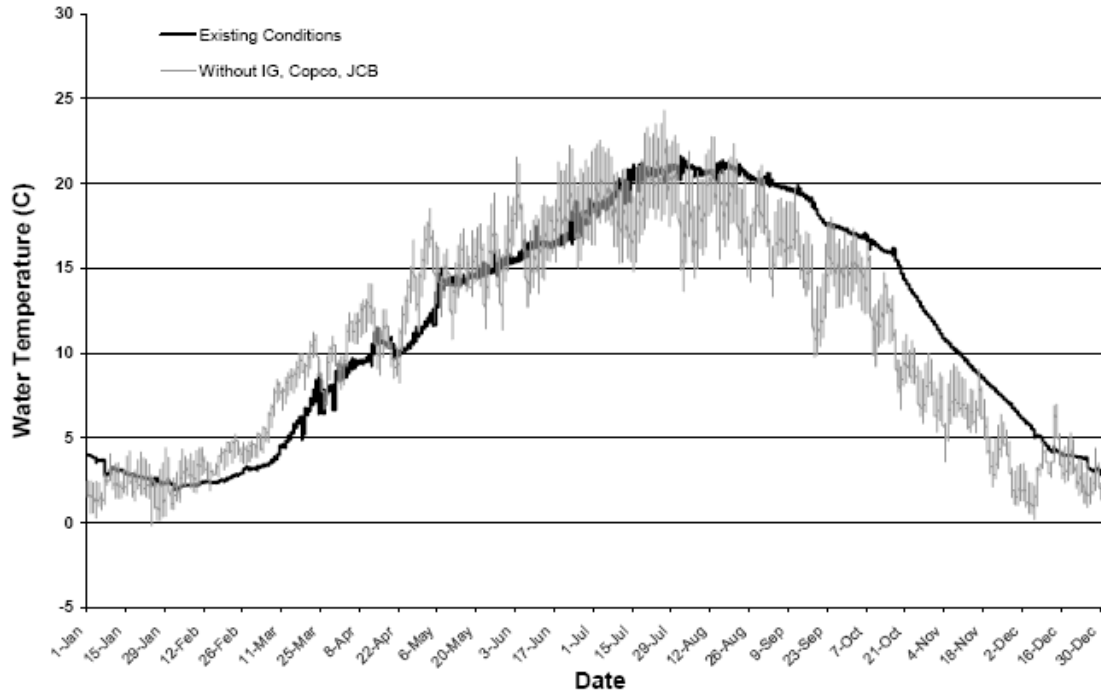
**Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in springtime water temperatures would be potentially significant while decreases in late summer/fall water temperatures would be beneficial.**

### Lower Klamath Basin

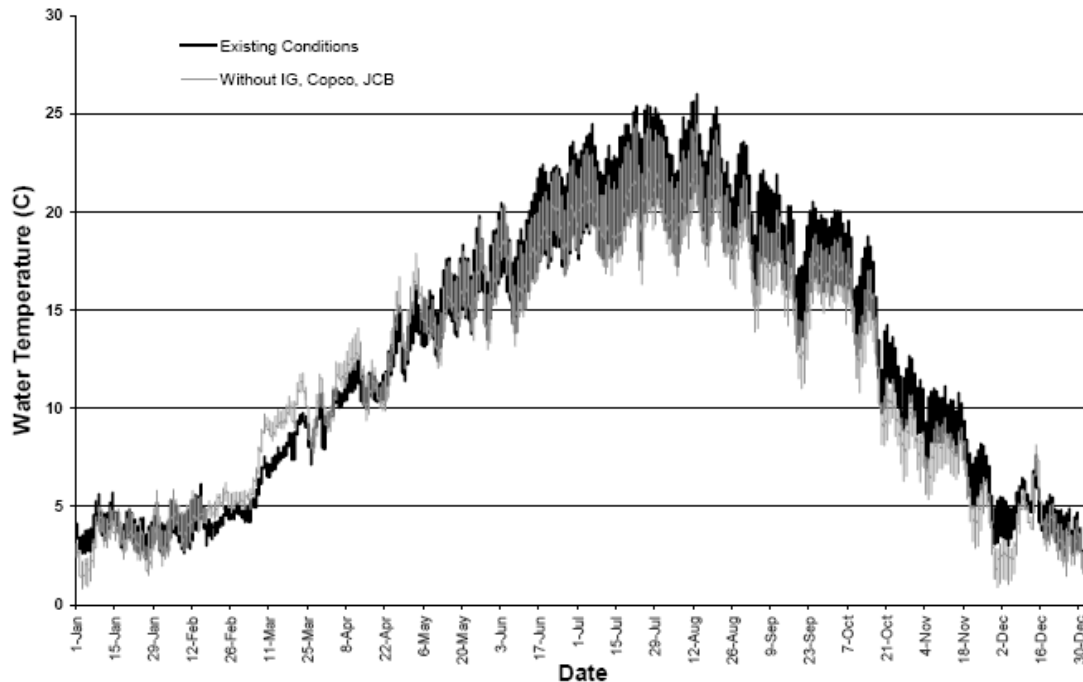
*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in spring water temperatures and decreases in late summer/fall water temperatures in the Lower Klamath River.* Water temperature modeling results are available for the Lower Klamath Basin from three separate modeling efforts: the PacifiCorp relicensing efforts (KRWQM; see Appendix D); development of the California Klamath River TMDLs (see Appendix D); and, water temperature modeling conducted for the Secretarial Determination studies (RBM10; see Appendix D). KRWQM results comparing the current condition (all KHP dams in place) to four without-project scenarios (i.e., no KHP dams; without Iron Gate Dam; without Copco 1, Copco 2, and Iron Gate; and without J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams) for 2001–2004 indicate that the reservoirs create a temporal shift by releasing generally cooler water from mid-January to April, variably cooler or warmer water from April through early August, and warmer water from August through November (PacifiCorp 2004a, Dunsmoor and Huntington 2006). Just downstream of Iron Gate Dam (RM 190.1), this translates to a 1–2.5°C (1.8–4.5°F) cooling during spring and a 2–10°C (3.6–18°F) warming during summer and fall (Figure 3.2-5). Immediately upstream of the confluence with the Scott River (RM 143.9), the difference between existing conditions and without-project scenarios indicates a lesser, albeit still measurable, warming of 2–5°C (3.6–9°F) for most of October and November (Figure 3.2-6). Because patterns in reservoir thermal structure for Iron Gate and Copco 1 indicate that stratification generally commences in April and ends in November, the effect of reservoir thermal regime on downstream water temperatures appears to be cooling during non-stratified periods and warming during stratified periods. The cooling effect in spring is potentially beneficial to rearing salmonids by reducing stress and disease for late outmigrants. The warming effect, which can be stressful to rearing salmonids, lasts for the majority of late summer and fall months and is of larger magnitude (PacifiCorp 2004a).

Reservoir thermal regimes also act to reduce the magnitude of daily temperature fluctuations in the reservoir reaches and the riverine reaches immediately downstream of Iron Gate Reservoir (RM 190.1; see Figure 3.2-5) (Deas and Orlob 1999, PacifiCorp 2004b). As with the seasonal temperature effect, the influence on daily temperature fluctuations is generally absent farther downstream, at the confluence with the Scott River (RM 143.9; see Figure 3.2-6). The KRWQM indicates that the temperature influence of the Hydroelectric Reach is mostly ameliorated by RM 66 at the confluence with the Salmon River (see Figure 3.2-7).

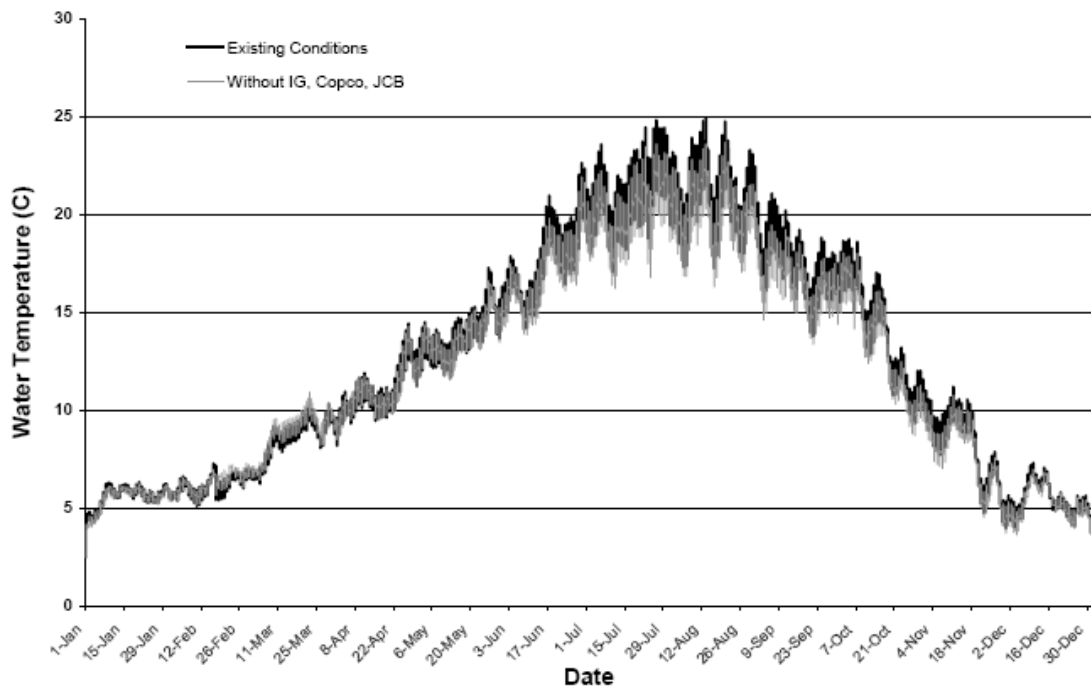




**Figure 3.2-5. Simulated Hourly Water Temperature Downstream of Iron Gate Dam (RM 190.1) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2004a.**



**Figure 3.2-6. Simulated Hourly Water Temperature Immediately Upstream of the Scott River Confluence (RM 143.9) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2004a.**



**Figure 3.2-7. Simulated Hourly Water Temperature Downstream of the Salmon River Confluence (≈RM 66) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2004a.**

In agreement with KRWQM results, Klamath TMDL model (see Appendix D) results also indicate that under the Proposed Action (similar to the TMDL TCD2RN scenario), water temperature in the Klamath River downstream of Iron Gate Dam (RM 190.1) would be 2–10°C (3.6–18°F) lower during August through November and 2–5°C (3.6–9°F) higher during January through March than those under the No Action/No Project (similar to the TMDL T4BSRN scenario), due to removal of the large thermal mass created by the reservoirs (NCRWQCB 2010a). The Klamath TMDL model also predicts that daily fluctuations in water temperature at this location during this same period would be greater under the Proposed Action (TCD2RN) than the No Action/No Project Alternative (T4BSRN) as water temperatures would be in equilibrium with (and would reflect) daily fluctuations in ambient air temperatures. As with KRWQM, these impacts would decrease in magnitude with distance downstream of Iron Gate Dam, and they would not be evident by the Salmon River confluence (≈RM 66). Therefore, under the Proposed Action, water temperatures would not be directly affected in the lower river downstream of the confluence with the Salmon River, including the Klamath Estuary and the marine nearshore environment.

As part of the Klamath Dam Removal Secretarial Determination studies, the effects of climate change were included in model projections for future water temperatures under the No Action/No Project Alternative and the Proposed Action. RBM10 model results using climate change predictions from five GCMs indicate that future water temperatures

under the Proposed Action (where simulated flows are subject to KBRA flows) would be 1–2.3°C (1.8–4.1°F) warmer than historical temperatures (Perry et al. 2011). This temperature range is slightly lower than that suggested by projecting Bartholow (2005) historical (1962–2001) estimates of 0.05°C (0.09°F) per year, or 2–3°C (3.6–5.4°F) over 50 years. However, within the general uncertainty of climate change projections, results from the two models correspond reasonably well and indicate that water temperatures in the Upper Klamath Basin are expected to increase with the period of analysis on the order of 1–3°C (1.8–5.4°F).

RBM10 results also indicate that, despite warming of water temperatures under climate change, the primary effect of dam removal is still anticipated be the return of approximately 160 miles of the Klamath River, from J.C. Boyle Reservoir (RM 224.7) to the Salmon River (RM 66), to a natural thermal regime (Perry et al. 2011). Model results indicate that the annual temperature cycle downstream of Iron Gate Dam would shift forward in time by approximately 18 days under the Proposed Action, with warmer temperatures in spring and early summer and cooler temperatures in late summer and fall immediately downstream of the dam. Just downstream of Iron Gate Dam, water temperatures under the Proposed Action including climate change would average 2°C greater in May than those under the No Action/No Project Alternative, while during October water temperatures would average 4°C cooler. At the confluence with the Scott River, the differences would be diminished, but there would still be a slight warming (<1 °C) in the spring and cooling (1–2 °C) in the late summer and fall (Perry et al. 2011). Thus, despite the anticipated warming under climate change, water temperature improvements under the Proposed Action would still help to achieve the Oregon and California temperature TMDLs for the mainstem Klamath River.

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020 (i.e., prior to reservoir thermal stratification), water temperature effects of the Proposed Action in the Klamath River downstream of Iron Gate Dam would occur, either partially or fully, within the first 1 to 2 years following dam removal and would be a short-term effect as well as a long-term effect.

**Under the Proposed Action, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in spring water temperatures for the reach from Iron Gate Dam to the confluence with the Salmon River would be potentially significant. Decreases in late summer/fall water temperatures would be beneficial. There would be no change from existing conditions on water temperatures for Klamath River downstream of the Salmon River, the Klamath Estuary, and the marine nearshore environment.**

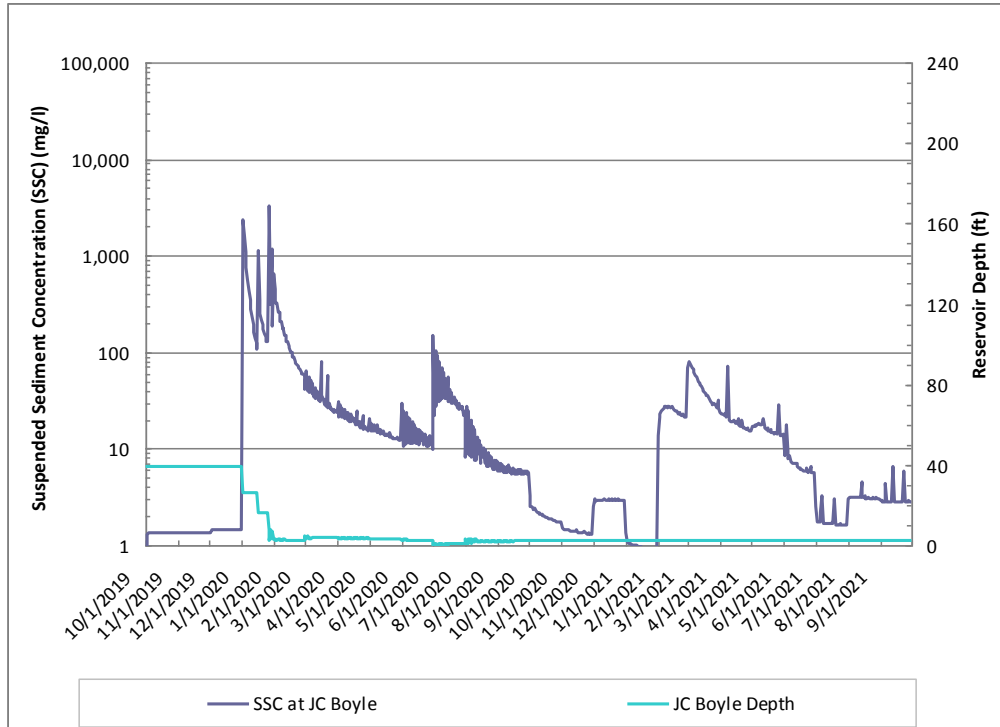
*Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) and/or long-term (2–50 years following dam removal) increases in sediment deposition in the Klamath River or Estuary that could alter morphological characteristics and indirectly affect*

*seasonal water temperatures.* Increased sediment deposition in the estuary under the Proposed Action may decrease the size of the salt wedge, either by increasing the frequency of mouth closure, or by elevating the bottom of the estuary above portions of the tidal range when the mouth is open. Alternately, scouring of current estuarine sediment deposits may occur during the short-term high sediment transport predicted to occur following dam removal, which may sufficiently change morphology as to effect mouth closure, salt wedge formation, and associated seasonal water temperatures. However, because little short-term settling, sedimentation, or scouring is expected to occur in the Klamath River or the estuary as a result of the Proposed Action (see Section 3.11.4.3), and estimates of baseline sediment delivery for the Klamath Basin indicate that long-term sediment delivery rates will not change substantially under the Proposed Action (Stillwater Sciences 2010), **there would be no indirect effect on water temperatures in the Klamath Estuary under the Proposed Action.**

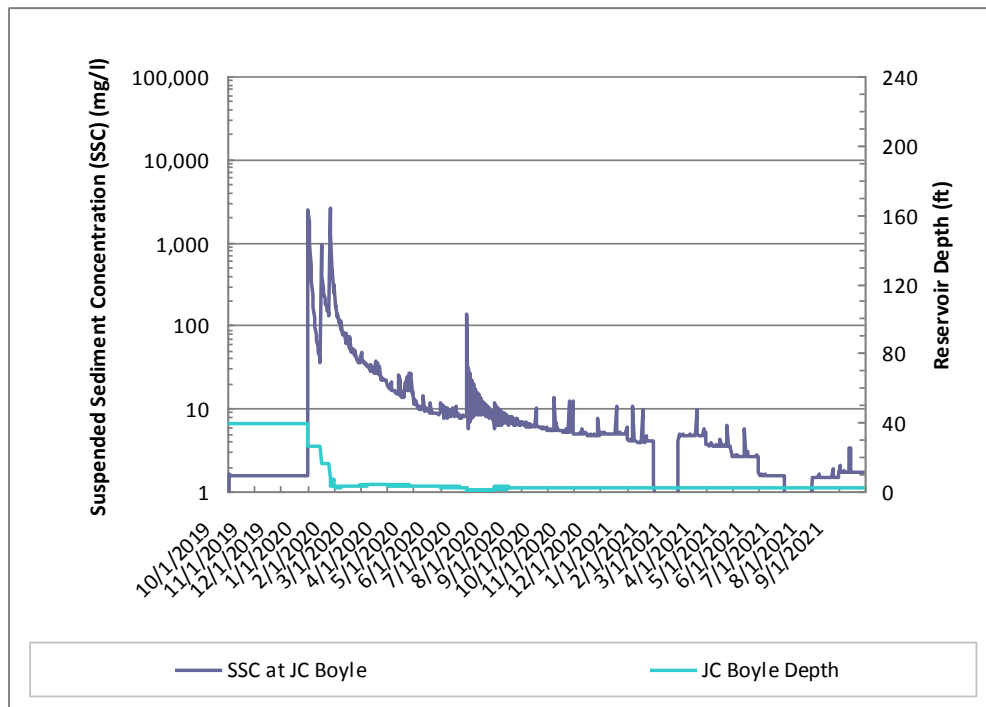
#### **3.2.4.3.2.2 Suspended Sediments**

##### Upper Klamath Basin

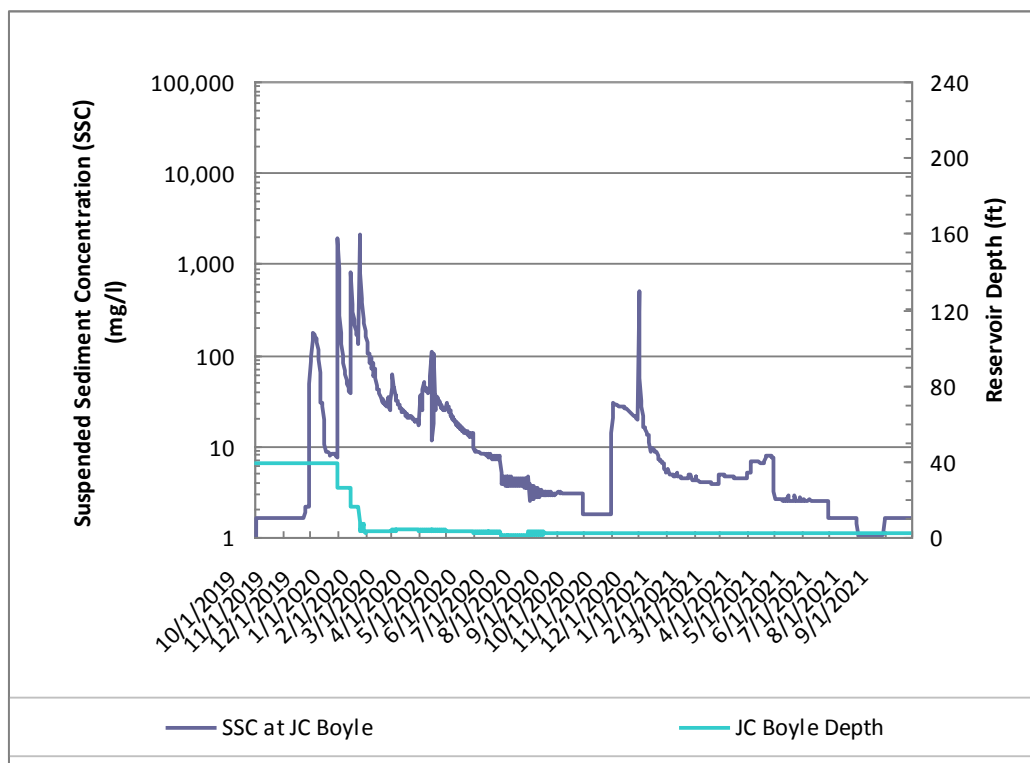
*Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) increases in suspended material in the Hydroelectric Reach downstream of J.C. Boyle Dam due to the release of sediments currently trapped behind the dams at the Four Facilities.* Results of sediment transport modeling of the impacts of dam removal on suspended sediment in the lower Klamath River indicate high short-term loads immediately downstream of Iron Gate Dam under the Proposed Action (Greimann et al. 2011, Stillwater Sciences 2008). Modeled SSCs downstream of J.C. Boyle Reservoir are similarly high in the short-term, although due to the relatively small volume of the sediment deposits behind J.C. Boyle Dam (i.e., 15 percent of total volume for the Four Facilities), concentrations would be considerably less than those anticipated to occur downstream of Iron Gate Reservoir. Overall, and within the general uncertainty of the model predictions, SSCs at J.C. Boyle Reservoir across the three water year types would have peak values of 2,000–3,000 mg/L and occurring within 1–2 months of reservoir drawdown. Predicted SSCs quickly decrease to less than 100 mg/L for 5–7 months following drawdown, and concentrations less than 10 mg/L for 6–10 months following drawdown (Figures 3.2-8 through 3.2-10). **Under the Proposed Action, the short-term (<2 years following dam removal) increases in SSCs in the Hydroelectric Reach downstream of J.C. Boyle Dam would be a significant impact.**



**Figure 3.2-8. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Dry Hydrology (WY2001).**



**Figure 3.2-9. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Median Hydrology (WY1976).**



**Figure 3.2-10. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Wet Hydrology (WY1984).**

*Stormwater runoff from deconstruction activities under the Proposed Action could cause short-term increases in suspended material in the Hydroelectric Reach during the deconstruction period.* Deconstruction activities under the Proposed Action would include demolition of the dams and their associated structures, power generation facilities, transmission lines, installation of temporary cofferdams, road upgrading, hauling, reservoir restoration, and other activities (as described in Section 2.4.3.1). Deconstruction activities are scheduled to occur between January 10 and June 26, with cofferdam installation scheduled to occur between 2 January 2020 and 6 February 2020. Therefore, cofferdam installation would occur during the first month of reservoir drawdown and the period of peak SSCs associated with mobilization of reservoir sediment deposits during drawdown. While the magnitude of short-term effects on SSCs due to erosion of the large volume of reservoir sediment deposits trapped behind the dams would be substantially greater than those due to dam deconstruction activities, this does not alleviate the requirement to reduce impacts from deconstruction-related activities. The potential for sediments to enter the Hydroelectric Reach from deconstruction site runoff, cofferdam installation, or in-water deconstruction work can be minimized or eliminated through the implementation of BMPs for deconstruction activities that would occur in or adjacent to the Klamath River (Appendix B). **Under the Proposed Action, the effect of stormwater runoff from deconstruction activities on**

**SSCs in the Hydroelectric Reach downstream of J.C. Boyle Dam would be a less-than-significant impact.**

*Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach.* The Proposed Action includes seven years of gravel placement (after an Affirmative Determination until 2019). Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking reaches. The spawning gravel would be placed using a passive approach before high flow periods, or to provide for other habitat enhancement in the Klamath River upstream of Copco 1 Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal. Passive gravel placement is specified by IM 7, which would avoid in-stream placement of gravel and would limit turbidity increases to periods of high river flow when turbidity is naturally elevated. The potential for sediments to enter the water during gravel placement along the river banks could be minimized or eliminated downstream of the enhancement sites through the implementation of BMPs for construction activities (Appendix B) (BLM 2011). Any disturbed sediments would be trapped by Iron Gate Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. **Under the Proposed Action, the effect of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, on SSCs in the Hydroelectric Reach would be a less-than-significant impact.**

*Implementation of IM 16, Water Diversions, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach due to diversion screening deconstruction and construction activities.* Under IM 16, PacifiCorp would seek to eliminate three screened diversions (the Lower Shovel Creek Diversion [7.5 cfs], Upper Shovel Creek Diversion [2.5 cfs], and Negro Creek Diversion [5 cfs]) from Shovel and Negro Creeks and would seek to modify its water rights to move the points of diversion from Shovel and Negro creeks to the mainstem Klamath River. If this were successful the screened diversions would be removed prior to dam removal in 2020. The intent of this measure is to provide additional water to Shovel and Negro creeks, thus increasing the quality and amount of suitable habitat for aquatic species within these tributaries, while not diminishing PacifiCorp's water rights. The potential for sediments to enter the water during screen removal activities is minimal if the diversions are individual pump intakes. If the diversions are larger concrete structures, the impacts would be of greater magnitude and longer duration, albeit still short-term and due to construction/deconstruction activities. In this case, impacts to SSCs can be minimized or eliminated through the implementation of BMPs for construction activities (Appendix B) stipulated during permitting of IM 16. Since IM 16 would be undertaken prior to dam removal, any disturbed sediments would be trapped by Copco 1 Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. The diversions would not be likely to affect other aspects of short-term or long-term water quality in the mainstem Klamath River since the water rights are relatively small (7.5 cfs, 2.5 cfs, and 5 cfs) compared to seasonal low flows in the mainstem upstream of Copco 1 Reservoir (typically >800 cfs). **Under the Proposed Action, the**

**effect of IM 16, Water Diversions, on SSCs in the Hydroelectric Reach in the J.C. Boyle Bypass Reach would be a less-than-significant impact.**

*Construction of the Yreka Pipeline under the Proposed Action could cause short-term increases in suspended material in the Hydroelectric Reach during the construction period.* For construction of the Yreka Pipeline, Dam Removal Entity (DRE) would construct a new, elevated pipeline and steel pipeline bridge to support the pipe above the river at the upstream end of Iron Gate Reservoir (see Section 2.4.3). The pipeline bridge would require in-water work in 2019 to build three concrete piers to support the bridge. Additional construction would occur along the Iron Gate Reservoir banks at each end of the new bridge where the new pipeline would be connected to the existing buried pipeline. The potential for sediments to enter the water during in-water pier construction and from construction site runoff can be minimized or eliminated in Iron Gate Reservoir through the implementation of BMPs for construction activities (Appendix B). Since the construction work will be undertaken in 2019, prior to dam removal, any disturbed sediments would be trapped by Iron Gate Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. **Under the Proposed Action, the effect of Yreka Pipeline construction activities on SSCs in the Hydroelectric Reach at the upstream end of Iron Gate Reservoir would be a less-than-significant impact.**

*Under the Proposed Action, recreational facilities currently located on the banks of the existing reservoirs will be removed following drawdown, and could release suspended sediment into the Klamath River.* The existing recreational facilities provide camping and boating access for recreational users of the reservoirs. Once the reservoirs are drawn down, these facilities will be removed. The potential for sediments to enter the water during the facilities removal will be minimized or eliminated through the implementation of BMPs for construction activities (Appendix B). Implementation of BMPs would ensure that impacts are constrained to the individual sites and their immediate area, and not transferred downstream in the Klamath River. **Under the Proposed Action, the short-term impacts on SSCs from the deconstruction of the recreational facilities would be less-than-significant.**

*Under the Proposed Action, revegetation associated with management of the reservoir footprint area could decrease the erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach.* Based on the reservoir area management planning currently underway, establishment of herbaceous vegetation in drained reservoir areas will be undertaken to stabilize the surface of the sediment and minimize erosion from exposed terrace surfaces following drawdown (O'Meara et al. 2010). Hydroseeding of herbaceous vegetation (i.e., grass) would be used, which typically entails applying a mixture of wood fiber, seed, fertilizer, and stabilizing emulsion to exposed slopes. Hydroseeding would be undertaken using a barge in spring 2020 while reservoir levels are high enough to operate and access the barge. Later in spring and summer 2020, aerial application would be necessary for precision applications of material near the newly established river channel, as well as in the remaining areas (see Section 2.3.4.5). Some



aerial fall seeding in 2020 might be necessary to supplement areas where spring hydroseeding was unsuccessful.

Hydroseeding would be undertaken using standard BMPs for reducing water quality impacts during deconstruction and/or construction activities and restoration projects (Appendix B). Additional BMPs specific to hydroseeding, such as avoiding over-spray onto roads, trails, existing vegetation, and the stream channel, would also be implemented so that the hydroseed mixture itself would not easily runoff or be directly sprayed into the Klamath River. **Under the Proposed Action, hydroseeding would decrease the short-term (<2 years following dam removal) erosion of fine sediments from exposed reservoir terraces into the river channel in the Hydroelectric Reach and would be beneficial.**

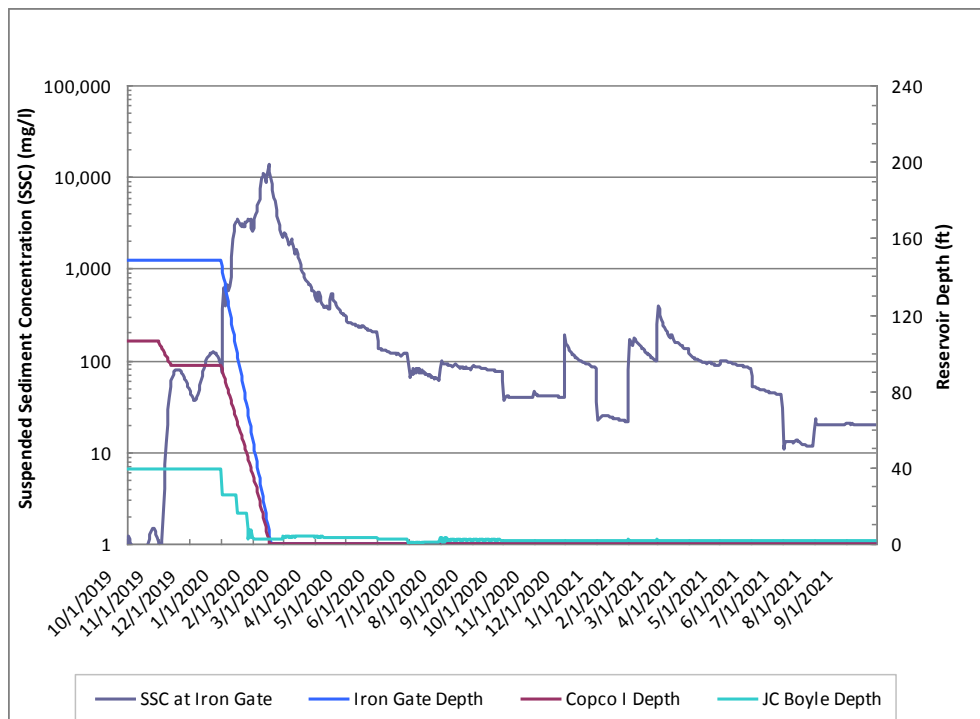
*Under the Proposed Action, the lack of continued interception and retention of mineral (inorganic) suspended material by the dams at the Four Facilities could result in long-term (2–50 years following dam removal) increases in suspended material in the Hydroelectric Reach.* Peak concentrations of mineral (inorganic) suspended material in the Hydroelectric Reach during the winter/early spring (November through April) would likely remain associated with high-flow events and any increases due to the lack of interception by the dams would not be large; estimates of baseline sediment delivery for the Klamath Basin indicate that a relatively small fraction of total sediment (199,300 tons per year or 3.4 percent of the cumulative average annual delivery from the basin) is supplied to the Klamath River on an annual basis from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) due to the generally lower rates of precipitation and runoff, more resistant and permeable geologic terrain, and relatively low topographic relief and drainage density of the Upper Klamath Basin as compared with the lower basin. (Stillwater Sciences 2010). **Under the Proposed Action, the long-term (2–50 years following dam removal) increase in mineral (inorganic) suspended material in the Hydroelectric Reach would be a less-than-significant impact.**

*Under the Proposed Action, the lack of continued interception and retention of algal-derived (organic) suspended material by the dams at the Four Facilities could result in slight long-term (2–50 years following dam removal) increases in suspended material in the Hydroelectric Reach.* Episodic increases (10–20 mg/L) in algal-derived (organic) suspended material resulting from in-reservoir algal productivity are not expected to occur in the Hydroelectric Reach following dam removal. SSCs in the Hydroelectric Reach may attain levels similar to those observed upstream of J.C. Boyle Dam under existing conditions during May through October (>15 mg/L; see Appendix C), as algal-dominated suspended material is transported downstream from Upper Klamath Lake. However, similar to the No Action/No Project Alternative, interception and retention of suspended material from upstream sources would still occur to a large degree in the Keno Impoundment (including Lake Ewauna), as would additional decreases in concentration due to mechanical breakdown of algal remains in the turbulent river reaches between Keno Dam and Copco 1 Reservoir, and dilution from the springs downstream of J.C. Boyle Dam. If slight long-term increases in suspended materials did occur, they would likely be offset by the loss of algal-derived suspended material previously produced in

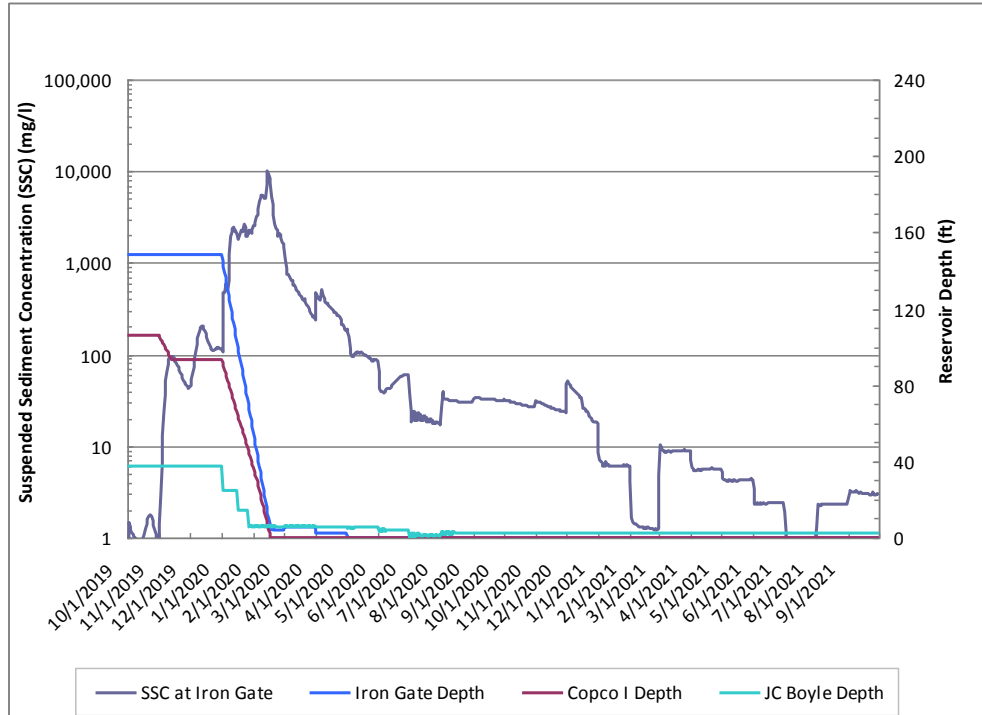
Copco 1 and Iron Gate Reservoirs and would not exceed levels that would substantially adversely affect the cold freshwater habitat (COLD) beneficial use (see discussion under Alternative 2 – Suspended Sediments – Lower Klamath Basin). **Under the Proposed Action, the long-term (2–50 years following dam removal) changes in algal-derived (organic) suspended material in the Hydroelectric Reach would be a less-than-significant impact.**

#### Lower Klamath Basin

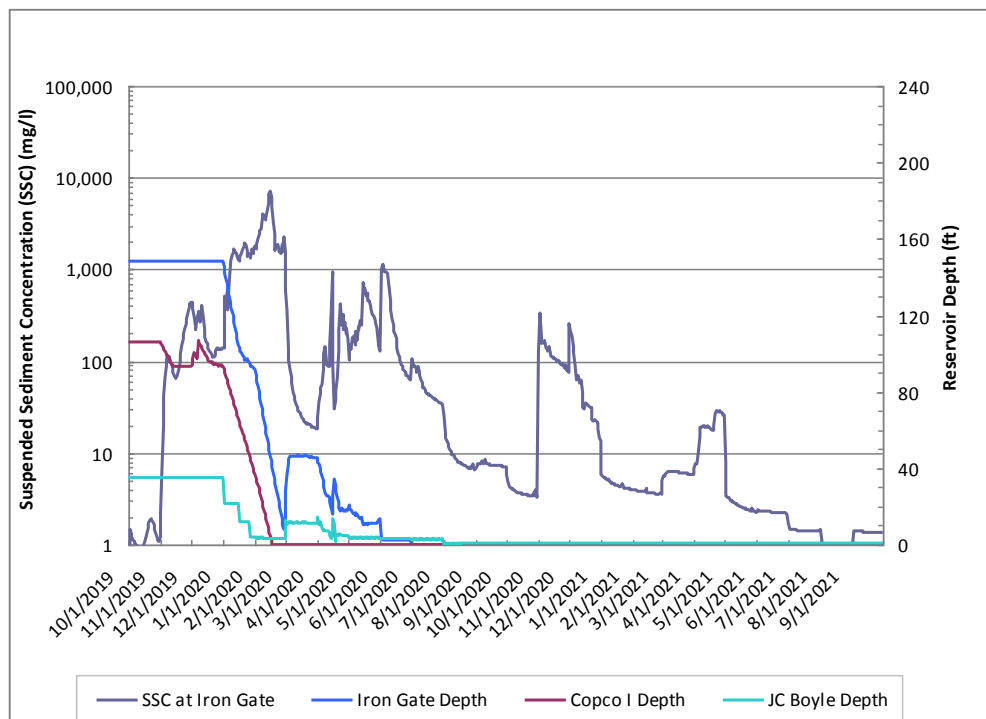
*Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) increases in suspended material in the lower Klamath River and the Klamath Estuary.* Sediment transport modeling of the impacts of dam removal on suspended sediment in the lower Klamath River indicates high short-term loads immediately downstream of Iron Gate Dam under the Proposed Action (Greimann et al. 2011, Stillwater Sciences 2008). The Proposed Action involves a three-phase drawdown for Copco 1 Reservoir beginning on November 1, 2019, and a single-phase drawdown for J.C. Boyle and Iron Gate Reservoirs beginning on January 1, 2020 (Greimann et al. 2011), which allows maximum SSCs to occur during winter months when flows are naturally high in the mainstem river. Suspended sediment model predictions for the Proposed Action are presented in Figure 3.2-11 through 3.2-13 for the three water year types (dry, median, wet) considered as part of the Secretarial Determination process. Model predictions are discussed below and summarized in Table 3.2-11.



**Figure 3.2-11. SSCs Modeled Downstream of Iron Gate Dam Under the Proposed Action Assuming Typical Dry Hydrology (WY2001).**



**Figure 3.2-12. SSCs Modeled Downstream of Iron Gate Dam Under the Proposed Action Assuming Median Hydrology (WY1976).**



**Figure 3.2-13. SSCs Modeled Downstream of Iron Gate Dam Under the Proposed Action Assuming Typical Wet Hydrology (WY1984).**

**Table 3.2-11. Summary of Model Predictions for SSCs in the Klamath River Downstream of Iron Gate Dam for the Proposed Action.**

Water Year Type	Peak SSC (mg/L)	SSC≥1,000 mg/L		SSC≥100 mg/L		SSC≥30 mg/L	
		Duration (Months)	Time Period	Duration (Months)	Time Period	Duration (Months)	Time Period
Dry (WY2001)	13,600	3	January–March 2020	6	January–June 2020	10	January–October 2020
Median (WY1976)	9,900	2	January–February 2020	5	January–May 2020	6	January–June 2020
Wet (WY1984)	7,100	2	January–February 2020	7	November 2019–February 2020 and April–June 2020	9	November 2019–July 2020

For typical dry year (WY2001) hydrologic conditions, predicted SSCs in the Klamath River immediately downstream of Iron Gate Dam (RM 190.1) experience a relatively small increase to near 100 mg/L in mid-November 2019 as Copco 1 undergoes the first phase of drawdown, and a large increase (>1,000 mg/L) in early January 2020 when Iron Gate and J.C. Boyle begin drawdown and Copco 1 enters phase 2 of drawdown. Concentrations remain very high (>1,000 mg/L) for approximately 3 months from January through April 2020 (see Figure 3.2-11), with peak values exceeding 10,000 mg/L to reach approximately 13,600 mg/L for a short period (4–5 days) in mid-February 2020. SSCs generally return to less than 100 mg/L by July 2020, and to concentrations near 30 mg/L by October 2020. Predicted SSCs increase again to levels between 200–400 mg/L during winter and spring of 2021 due to flushing of sediments that were not removed during the first year following drawdown.

Model predictions for median year (WY1976) hydrologic conditions follow a pattern similar to that of a typical dry year (WY2001), with a relatively small increase in SSCs (i.e., to near 200 mg/L) in mid-December 2019, and a large (>1,000 mg/L) increase again in early January 2020. Peak SSCs downstream of Iron Gate Dam are predicted to be lower for the median year condition, reaching levels just under 10,000 mg/L. Relative to the typical dry year, the lower median year peak SSCs are a result of greater flows flushing the same volume of sediment out of the reservoir and downstream. Peak concentrations also occur in mid-February 2020 for the median year hydrologic condition (see Figure 3.2-12). Predicted SSCs downstream of Iron Gate Dam (RM 190.1) remain very high (>1,000 mg/L) for approximately 2 months following the inception of drawdown in Iron Gate and Copco 1 Reservoirs, from January through February 2020. There is a slightly earlier return to SSCs less than 100 mg/L for the median year (WY1976), with concentrations decreasing by May 2020. SSCs decrease to less than 30 mg/L by June 2020, and fluctuate between 10 mg/L and 100 mg/L through the remainder

of 2020. The increases above 100 mg/L are not predicted for the typical median water year condition in the year following dam removal (2021), but fluctuating SSCs may occur in the second year following dam removal due to erosion of sediment deposits remaining in the reservoir footprint area.

Model predictions for typical wet year (WY1984) hydrologic conditions indicate a higher initial pulse of fine sediments following the first phase of Copco 1 drawdown in early to mid-December 2019, with concentrations at or near 400 mg/L. Model predictions indicate that for typical wet year conditions, the outlet capacity at Copco 1 Dam is exceeded during the same timeframe and the reservoir fills slightly (see Figure 3.2-13). Very high ( $>1,000$  mg/L) SSCs are experienced for approximately 2 months following the inception of drawdown in the reservoirs, from January through February 2020 (see Figure 3.2-13). SSCs reach approximately 7,100 mg/L, with peak values occurring in mid-February 2020. Secondary peaks ( $\approx 1,000$  mg/L) in SSCs occur in mid-April and June 2020 for wet year (WY1984) hydrologic conditions. SSCs generally return to less than 100 mg/L during the month of March 2020 and then again by July 2020. Concentrations return to less than 30 mg/L by July 2020.

For all three water year types, predicted SSCs in the lower Klamath River decrease to 60–70 percent of their value at Iron Gate Dam by Seiad Valley (RM 129.4) and to 40 percent of their initial value downstream of Orleans ( $\approx$ RM 59) (Greimann et al. 2011).

Overall, and within the general uncertainty of the model predictions, SSCs across the three water year types would have peak values of 7,000–14,000 mg/L and occurring within 2–3 months of reservoir drawdown. Predicted SSCs would remain greater than or equal to 100 mg/L for 5–7 months following drawdown, and concentrations would remain greater than or equal to 30 mg/L for 6–10 months following drawdown (Table 3.2-11). Model results also indicate that while dilution in the lower river would decrease SSCs to 60–70 percent of their initial value downstream of Seiad Valley (RM 129.4) and to 40 percent of their initial value downstream of Orleans ( $\approx$ RM 59), within a factor of 2 uncertainty for the model results it can be conservatively assumed that SSCs in the lower Klamath River would be sufficient ( $\geq 30$  mg/L) to substantially adversely affect beneficial uses throughout the lower River and the Klamath Estuary for 6–10 months following drawdown (Greimann et al. 2011). A more detailed analysis of the anticipated suspended sediment effects on key fish species in the lower river is presented in Section 3.3.4.3.

Overall, sediment release associated with the Proposed Action would cause short-term increases in suspended material ( $\geq 30$  mg/L for 6–10 months following drawdown) that would result in non-attainment of applicable North Coast Basin Plan water quality objectives for suspended material in the lower Klamath River and the Klamath Estuary and would substantially adversely affect the cold freshwater habitat (COLD) beneficial use. **Under the Proposed Action, the short-term ( $<2$  years following dam removal) increases in SSCs in the lower Klamath River and the Klamath Estuary would be a significant impact.**

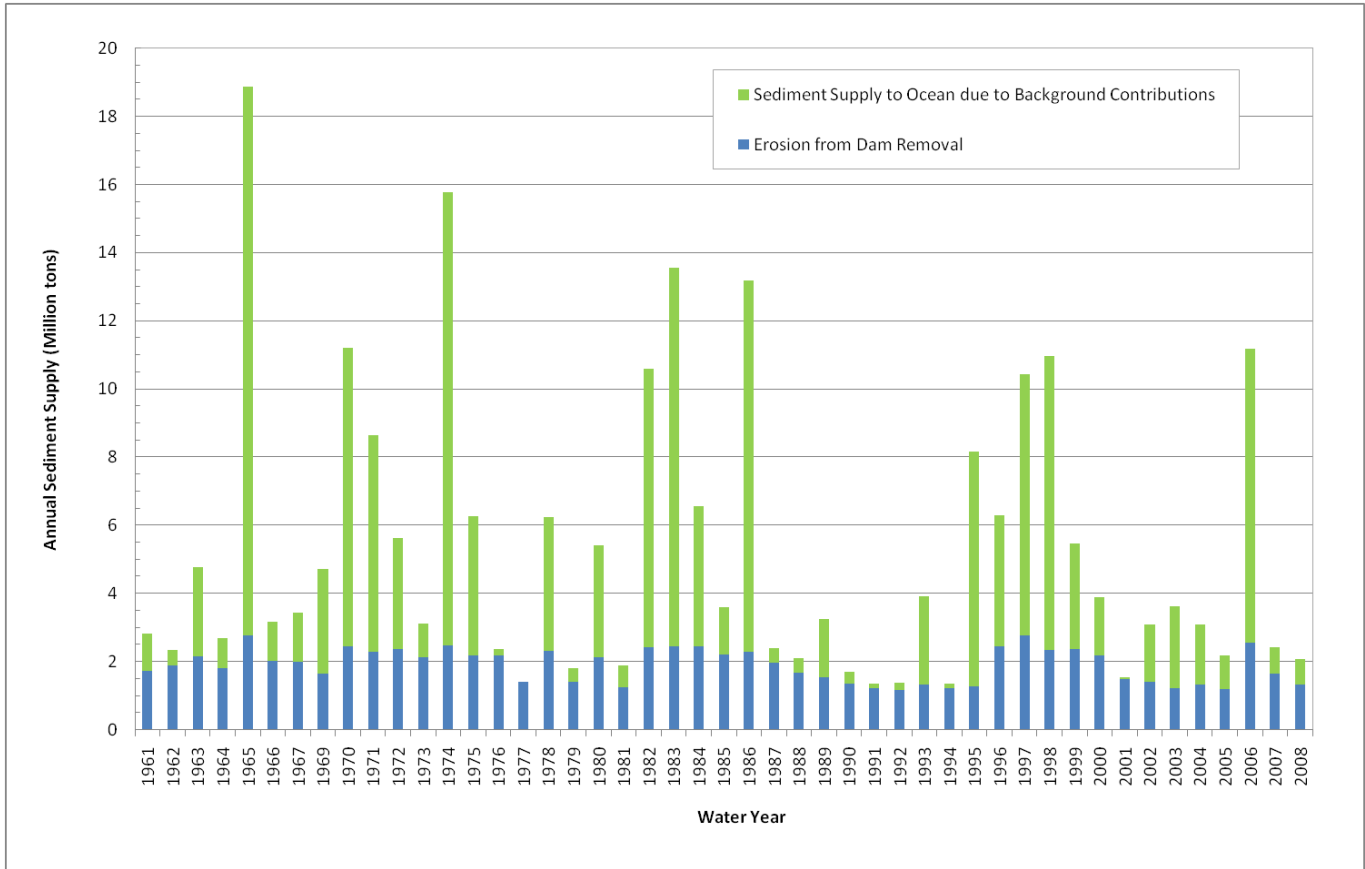
*Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) increases in sediment loads from the Klamath River to the Pacific Ocean and corresponding increases in concentrations of suspended material and rates of deposition in the marine nearshore environment.* The results of model predictions for sediment transport following dam removal under the Proposed Action indicate that dam removal would cause a release of less than 3 million tons of fine sediment to the Klamath River downstream of Iron Gate Dam (see Figure 3.2-14). While estimates of long-term average annual sediment discharge to the Klamath Estuary vary considerably, they are generally well above the projected 3 million tons. For example, annual sediment supply from Trinity River alone is calculated to be 8.5 million tons based on data provided in USEPA (2001). Additionally, Stillwater Sciences (2010) estimated that Klamath River annual sediment discharge to the estuary is approximately 5.8 million tons<sup>6</sup>. The predicted sediment release due to dam removal under the Proposed Action ranges from 1.5 to 2.6 million tons depending on water year type (see Figure 3.2-14) and is only about one eighth of the cumulative sediment transport in the Klamath River at Hoopa in a four-day period during the December 1964 flood event. Lastly, the predicted sediment release due to dam removal is approximately the same as the cumulative sediment transport over a single day at the Salmon River confluence during a very large flood event (i.e., the January 1974 flood) (Stillwater Sciences 2010).

After exiting the river mouth, the high SSCs (>1,000 mg/L) transported by the lower Klamath River would form a surface plume of less dense, turbid, surface water floating on more dense, salty ocean water (Mulder and Syvitski 1995). No detailed investigations of the likely size and dynamics of the Klamath River plume have been conducted. Thus, it is not possible to predict accurately the sediment deposition pattern and location in the nearshore environment. However, the general dynamics and transport mechanisms of fine sediment can be surmised based upon regional oceanographic and sediment plume studies.

The California Marine Life Protection Act (MLPA) 2008 Draft Master Plan identifies freshwater plumes as one of three prominent habitats with demonstrated importance to coastal species (California Marine Life Protection Act 2008). The California MLPA Master Plan Science Advisory Team (2011) Methods Report designates river plumes as a key habitat to be included in marine protected areas because they harbor a particular set of species or life stages, have special physical characteristics, or are used in ways that differ from other habitats.

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<sup>6</sup> The estimated Klamath River sediment supply to the estuary by Farnsworth and Warrick (2007) is 1.2 million tons per year, but this estimate is likely low because their estimated upper bound of 1.7 million tons is much lower than observations. The calculated sediment transport based on field data for the period of 22 through 26 December 1964, for example, is more than 25 million tons (Stillwater Sciences 2010). As a result, the Farnsworth and Warrick (2007) estimate of Klamath River sediment delivery is not used for direct comparisons here.



**Figure 3.2-14. Annual predicted sediment delivery to the Pacific Ocean under the Proposed Action and the No Action (background conditions) by Water Year.**  
**Note: model results are only valid for the year of dam removal. No significant increase in sediment loads is predicted in years following dam removal (Source: Greimann et al. 2011).**

A recent USGS overview report on the sources, dispersal, and fate of fine sediment delivered to California's coastal waters (Farnsworth and Warrick 2007) found the following:

- Rivers dominate the supply of fine sediment to the California coastal waters, with an average annual flux of 34 million metric tons.
- All California coastal rivers discharge episodically, with large proportions of their annual sediment loads delivered over the course of only a few winter days.
- After heavy loading of fine sediment onto the continental shelf during river floods, there is increasing evidence that fluid-mud gravity flows occur within a layer 10 to 50 cm above the seabed and efficiently transport fine sediment offshore.
- Although fine sediment dominates the mid-shelf mud belts offshore of California river mouths, these mud belts are not the dominant sink of fine sediment, much of

which is deposited across the inner shelf and deeper water off the continental shelf.

- Accumulation rates of fine sediment, which can exceed several millimeters per year, are generally highest near river sources of sediment and along the inner shelf and midshelf.

Farnsworth and Warrick (2007) conclude that fine sediment is a natural and dynamic element of the California coastal system because of large, natural sediment sources and dynamic transport processes.

In northern California, plume zones are primarily north of river mouths because alongshore currents and prevailing winds are northward during periods of strong runoff (Geyer et al. 2000, Pullen and Allen 2000, Farnsworth and Warrick 2007, California MLPA Master Plan Science Advisory Team 2011). Surface plumes occurring during periods of northerly (upwelling favorable) winds will thin and stretch offshore, while in the presence of southern downwelling-favorable winds, the plume may hug the coastline and mix extensively (Geyer et al. 2000, Pullen and Allen 2000, Borgeld et al. 2008). River plume area, location, and dynamics are also affected by the magnitude of river discharge, SSCs, tides, the magnitude of winter storms, and regional climatic and oceanographic conditions such as El Niño-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) climate cycles (Curran et al. 2002).

During several large flood events on the geographically proximal Eel River in the winter of 1997 and 1998, Geyer et al. (2000) found the following: flood conditions were usually accompanied by strong winds from the southern quadrant. The structure of the river plume was strongly influenced by the wind-forcing conditions. During periods of strong southerly (i.e., downwelling favorable) winds, the plume was confined inside the 50-m isobath (i.e., sea floor contour at 50-m below the water surface), within about 7 km of shore. Occasional northerly (upwelling favorable) winds arrested the northward motion of the plume and caused it to spread across the shelf. Transport of the sediment plume was confined to the inner shelf (water depths less than 50 m), during both southerly and northerly wind conditions. During southerly wind periods, fine, un-aggregated sediment was rapidly transported northward to at least 30 km from the river mouth, but flocculated sediment was deposited within 1–10 km of the river mouth. During northerly (upwelling-favorable) winds, most of the sediment fell out within 5 km of the mouth, and negligible sediment was carried offshore. The Eel River mouth is 120 km (75 miles) to the south of the Klamath River mouth and thus serves as a reasonable system for comparison.

Based upon Eel River plume studies and current knowledge of northern California oceanographic patterns, the fine sediment discharged to the marine nearshore environment under the Proposed Action would likely be delivered to the ocean in a buoyant river plume that hugs the shoreline as it is transported northward. However, since the flushing of sediments from behind the dams will occur over a number of weeks to months (and perhaps to some degree over 1-2 years), the plume carrying reservoir sediments would likely be influenced by a range of meteorological and ocean conditions (e.g., storm and non-storm periods, differing storm directions). Therefore, some of the



time the plume would likely be constrained to shallower nearshore waters, while at other times it would likely extend further offshore and spread more widely. While elevated SSCs (i.e., 10–100 mg/L) created in the nearshore plume would affect physical water quality characteristics specified in the Ocean Plan (i.e., visible floating particulates, natural light attenuation, the deposition rate of inert solids [Table 3.2-7]), the effects are likely to be within the range caused by historical storm events.

A 1995 Eel River flood with a 30-yr return period delivered an estimated  $25 \pm 3$  million metric tons of fine-grained ( $<62 \mu\text{m}$ ) sediment to the ocean (Wheatcroft et al. 1997). Transported sediments formed a distinct layer on the sea bed that was centered on the 70-m isobath, extended for 30 km along shelf and 8 km across shelf, and was as thick as 8.5 cm. Wheatcroft et al. (1997), estimated that 75% of the flood-derived sediment did not form a recognizable sea-floor deposit, but was instead rapidly and widely dispersed over the continental margin.

A considerable amount of fine sediment in the plume is anticipated to initially deposit on the seafloor shoreward of the 60-m isobath along the coast, with greater quantities depositing in close proximity to the mouth of the Klamath River. After this initial deposition, as described by Farnsworth and Warrick (2007), resuspension during the typical winter storms would likely occur before final deposition and burial. Much of this sediment will eventually be transported further offshore to the mid-shelf and into deeper water depths off-shelf through progressive resuspension and fluid-mud gravity flows.

Because of the complexities of the transport processes, the area and depth of the deposition of fine sediment from the Proposed Action cannot be precisely predicted. However, the short-term ( $< 2$  years following dam removal) plume effects and long-term (2-50 years following dam removal) sediment deposit effects would be less-than-significant given the relatively small amount of total sediment input, in comparison to the total annual sediment inputs to the nearshore environment, and the fact that river plume sediment inputs are a naturally occurring process. As a result, net deposition of reservoir sediments to the marine nearshore bottom substrates should be relatively less concentrated (i.e., thinner deposits in any one spot) and more widespread.

In summary, due to the relatively small magnitude of SSCs released to the nearshore environment, the anticipated rapid dilution of the sediment plume as it expands in the ocean, and the relatively low rate of deposition of sediments to the marine nearshore bottom substrates, **the short-term ( $< 2$  years following dam removal) increases in SSCs and fine sediment deposition in the marine nearshore environment under the Proposed Action would be a less-than-significant impact.**

*Stormwater runoff from deconstruction activities under the Proposed Action could cause increases in suspended material in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment during the deconstruction period. Deconstruction activities under the Proposed Action would include demolition of the dams and their associated structures, power generation facilities, transmission lines, installation of temporary cofferdams, road upgrading, hauling, reservoir restoration, and other activities*

(as described in Section 2.4.3.1). Deconstruction activities are scheduled to occur between January 10 and June 26, with cofferdam installation scheduled to occur between 2 January 2020 and 6 February 2020. Therefore, cofferdam installation would occur during the first month of reservoir drawdown and the period of peak SSCs associated with mobilization of reservoir sediment deposits during drawdown. While the magnitude of short-term effects on SSCs due to erosion of the large volume of reservoir sediment deposits trapped behind the dams would be substantially greater than those due to dam deconstruction activities, this does not alleviate the requirement to reduce impacts from deconstruction-related activities. Although suspended materials from deconstruction would not likely reach the Klamath Estuary or marine nearshore environment, the potential for sediments to enter the water from deconstruction site runoff or in-water deconstruction work can be minimized or eliminated through the implementation of BMPs for deconstruction activities that would occur in or adjacent to the Klamath River. **Under the Proposed Action, the effect of stormwater runoff from deconstruction activities on SSCs in the lower Klamath River and the Klamath Estuary would be a less-than-significant impact. There would be no change from existing conditions on the marine nearshore environment.**

*Under the Proposed Action, revegetation associated with management of the reservoir footprint area could decrease the transport of fine sediments eroded from exposed reservoir terraces into the lower Klamath River and Klamath Estuary.* As described for the Upper Klamath Basin, establishment of herbaceous vegetation in drained reservoir areas will be undertaken to stabilize the surface of the sediment and minimize erosion from exposed terrace surfaces following drawdown (O'Meara et al. 2010). Hydroseeding would be undertaken using standard BMPs for reducing water quality impacts during deconstruction and/or construction activities and restoration projects (Appendix B). Additional BMPs specific to hydroseeding, such as avoiding over-spray onto roads, trails, existing vegetation, and the stream channel, would also be implemented so that the hydroseed mixture itself would not easily runoff or be directly sprayed into the Klamath River. **Under the Proposed Action, hydroseeding would decrease the short-term (<2 years following dam removal) transport of fine sediments eroded from exposed reservoir terraces into the lower Klamath River and Klamath Estuary and would be beneficial. There would be no change from existing conditions on the marine nearshore environment.**

*Under the Proposed Action, the lack of continued interception and retention of mineral (inorganic) suspended material behind the dams at the Four Facilities could result in long-term (2–50 years following dam removal) increases in suspended material in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.* As would be the case for the Upper Klamath Basin, peak concentrations of mineral (inorganic) suspended materials in the Lower Klamath Basin during the winter/early spring (November through April) would likely remain associated with high-flow events and any increases due to the lack of interception by the KHP dams would not be large; estimates of baseline sediment delivery for the Klamath Basin indicate that a relatively small fraction of total sediment (199,300 tons/yr or 3.4 percent of the cumulative average annual delivery from the basin) is supplied to the Klamath River on an annual basis from

the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) (Stillwater Sciences 2010).

**Under the *Proposed Action*, the long-term (2–50 years following dam removal) increases in mineral (inorganic) suspended material in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.**

*Under the Proposed Action, the lack of continued interception and retention of algal-derived (organic) suspended material by the dams at the Four Facilities could result in slight long-term (2–50 years following dam removal) increases in suspended material in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.* While removal of the Four Facilities would eliminate the potential for downstream increases in suspended material due to seasonal algal blooms occurring within the reservoirs at the Four Facilities, overall sediment trapping in the Hydroelectric Reach would no longer occur, such that, in the long-term, summertime algal-derived suspended material originating from Upper Klamath Lake may move farther downstream into the lower basin and cause a relative increase in suspended material. However, similar to the No Action/No Project Alternative, interception and retention of suspended material from upstream sources would still occur to a large degree in the Keno Impoundment (including Lake Ewauna), as would additional decreases in concentration due to mechanical breakdown of algal remains in the turbulent river reaches between Keno Dam and Copco 1 Reservoir, and dilution from the springs downstream of J.C. Boyle Dam.

Because existing conditions indicate that average June–October suspended sediment values decrease from over 16 mg/L at the mouth of Link River to 6 mg/L in the Klamath River downstream of J.C. Boyle Reservoir (2001–2003), with median turbidity values following a similar pattern over the long-term historical record (1950–2001) (see Section 3.2.3.1 and Appendix C, Section C.2), it is likely that the suspended sediment signal would not increase beyond typical existing conditions concentrations of 10–15 mg/L. Therefore, summertime suspended sediment in the lower Klamath River is unlikely to increase beyond a sustained 30 mg/L for four weeks, the water quality criterion adopted for significant adverse impacts on the cold freshwater habitat (COLD) beneficial use for the Klamath Facilities Removal EIS/EIR analysis (see Section 3.2.4.2.2.1). If slight long-term increases in suspended materials did occur, they would likely be offset by the loss of algal-derived suspended material previously produced in Copco 1 and Iron Gate Reservoirs and would not exceed levels that would substantially adversely affect the cold freshwater habitat (COLD) beneficial use.

**Under the *Proposed Action*, the long-term (2–50 years following dam removal) increases algal-derived (organic) suspended material in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.**

### 3.2.4.3.2.3 Nutrients

#### Upper Klamath Basin

*Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) increases in sediment-associated nutrients.* Short-term increases in TN and TP concentrations in the Hydroelectric Reach would occur because particulate (primarily organic) nutrients contained in reservoir sediment deposits would be transported along with the sediments themselves. However, minimal deposition of fine suspended sediments, including associated nutrients, would occur in the river channel (Greimann et al. 2011, Stillwater Sciences 2008). Further, reservoir drawdown under the Proposed Action would occur during winter months when rates of primary productivity and microbially mediated nutrient cycling (e.g., nitrification, denitrification) are also expected to be low. Light limitation for primary producers that do persist during winter months is also likely to occur, further decreasing the potential for uptake of TN and TP released along with reservoir sediment deposits. Therefore, particulate nutrients released along with sediment deposits are not expected to be bioavailable and should be well-conserved during transport through the Hydroelectric Reach. **Under the Proposed Action, the short-term (<2 years following dam removal) increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact.**

*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could cause long-term (2–50 years following dam removal) increases in nutrient levels in the Hydroelectric Reach.* The Four Facilities intercept and retain suspended material behind the dams, including phosphorus and nitrogen originating from Upper Klamath Lake (see Section 3.2.3.1). Under the Proposed Action, these nutrients would be transported downstream and potentially be available for uptake (e.g., by nuisance algae species). Analyses of the effects of dam removal on nutrients have been conducted by PacifiCorp for its relicensing efforts (FERC 2007), NCRWQCB for development of the California Klamath River TMDLs (NCRWQCB 2010a), and the Yurok Tribe as part of an evaluation to improve previous mass-balance estimates of nutrients in the Klamath River and increase understanding of retention rates in free-flowing river reaches (Asarian et al. 2010). While the results of all of the evaluations recognize the trapping efficiency of the reservoirs with respect to TP and TN, such that under the Proposed Action total nutrient concentrations in the Klamath River downstream of Iron Gate Dam would increase, the majority of the results are focused on the Klamath Basin downstream of Iron Gate Dam.

However, modeling conducted for development of the California Klamath River TMDLs (NCRWQCB 2010a) provides some information applicable to the assessment of long-term (2–50 years following dam removal) effects of the Proposed Action on nutrients at locations in the Upper Klamath Basin (i.e., upstream of Iron Gate Dam) (Kirk et al. 2010). Klamath TMDL model results indicate that under the Proposed Action (similar to the TMDL TOD2RN scenario, which includes Oregon TMDL allocations), TP and TN in the Hydroelectric Reach immediately downstream of J.C. Boyle Dam would increase slightly (<0.015 mg/L and <0.05 mg/L, respectively) during summer months compared to those of the No Action/No Project Alternative (similar to the TMDL T4BSRN scenario)

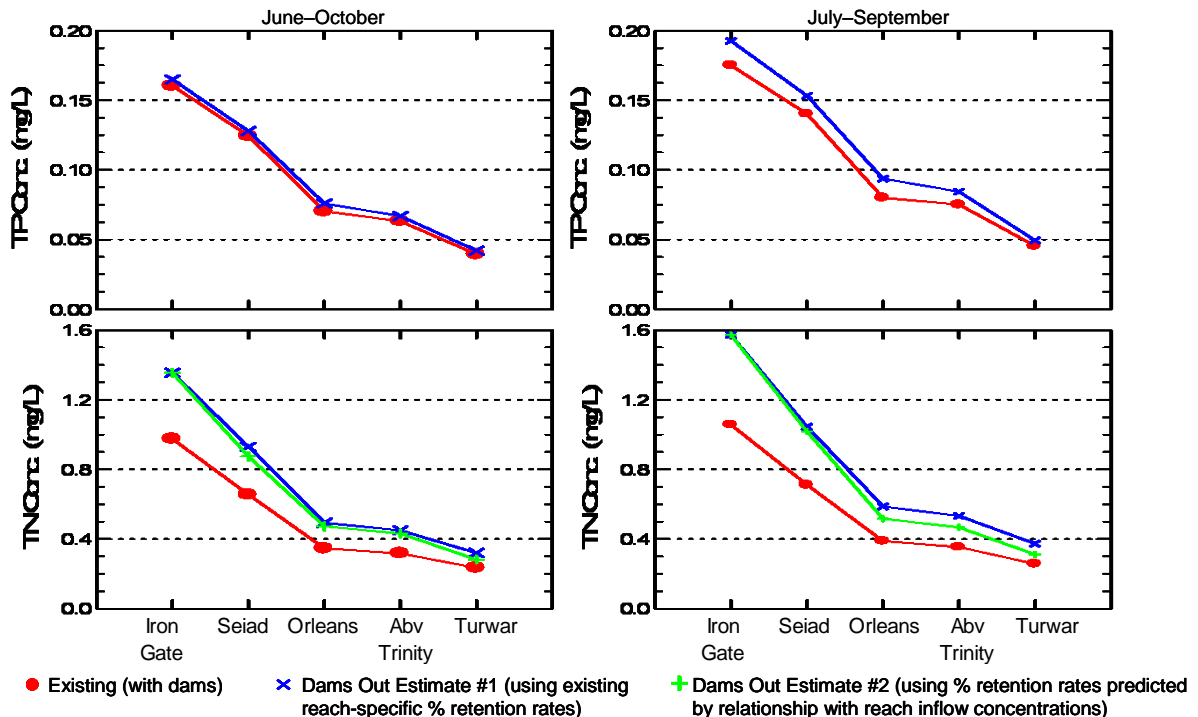
due to the absence of nutrient interception and retention in both Keno Impoundment and J.C. Boyle Reservoir (the former because the TMDL model TOD2RN scenario includes the historic Keno Reef instead of Keno Dam [Appendix D]). At the Oregon-California state line, the situation would be much the same, although the lack of hydropower peaking operations under the Proposed Action may result in decreased daily variation in TP and ortho-phosphorus, as well as nitrate and ammonium (NCRWQCB 2010a). Overall however, the predicted increases would be very small and these increases may be at least partially due to the assumption that the historic Keno Reef exists rather than Keno Dam. Regardless, the increases would not be expected to result in exceedances of either Oregon water quality objectives for nuisance algae growth, or California North Coast Basin Plan water quality objectives for biostimulatory substances, beyond levels experienced under the No Action/No Project Alternative. Further, the lacustrine environment that supports the growth of nuisance algae blooms of such as *M. aeruginosa* or other cyanobacteria would be eliminated under the Proposed Action (see Section 3.4, Algae), reducing the likelihood of uptake of the slightly increased nutrient concentrations by nuisance algae species. **Under the Proposed Action, the long-term (2–50 years following dam removal) increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact.**

#### Lower Klamath Basin

*Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) increases in sediment-associated nutrients in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.* **Under the Proposed Action, the short-term (<2 years following dam removal) increase in nutrients in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be the same as in the Hydroelectric Reach and would be a less-than-significant impact.**

*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could cause long-term (2–50 years following dam removal) increases in nutrient levels in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.* The reservoirs at the Four Facilities currently intercept and retain suspended material behind the dams, including phosphorus and nitrogen originating from Upper Klamath Lake (see Section 3.2.3.1). Under the Proposed Action, these nutrients would be transported downstream and potentially be available for uptake by algae, including nuisance algae species. Analyses of the effects of dam removal on nutrients have been conducted by PacifiCorp for its relicensing efforts (FERC 2007), NCRWQCB for development of the California Klamath River TMDLs (NCRWQCB 2010a), and the Yurok Tribe as part of an evaluation to improve previous mass-balance estimates of nutrients in the Klamath River and increase understanding of retention rates in free-flowing river reaches (Asarian et al. 2010). Results of all of the evaluations recognize the trapping efficiency of the reservoirs with respect to TP and TN, such that under the Proposed Action total nutrient concentrations in the Klamath River downstream of Iron Gate Dam would increase.

Based on the Yurok Tribe analysis, TP concentrations would increase approximately 2-12 percent for the June–October period under the Proposed Action, while increases in TN concentrations would be relatively larger, at an estimated 37-42 percent for June–October and 48-55 percent for July–September (see Figure 3.2-15). Asarian et al. (2010) conducted their analysis using two different approaches; 1) calculated reach-specific nutrient retention rates based on measured nutrient concentration data, and 2) predicted retention rates using an empirical relationship between observed retention rates and measured concentrations developed for the river from Iron Gate Dam to Turwar (this approach was only applicable to TN because TP data demonstrated a weak relationship between retention rate and measured TP concentrations). Both approaches yield similar results, indicating small increases in TP and relatively larger increases in TN concentrations downstream of the Hydroelectric Reach under the Proposed Action, which diminish with distance downstream due to both tributary dilution and nutrient retention (i.e., uptake of nutrients).



**Figure 3.2-15. Comparison of TP and TN Concentrations from Iron Gate Dam to Turwar (RM 5.8) for June–October and July–September 2007–2008: (a) Measured Current Conditions (Red Circle), (b) Dams-Out Estimate using Calculated Percent Retention Rates by Reach (Blue Cross), and (c) Dams-Out Estimate using Percent Retention Rates Predicted by the Empirical Relationship between Reach Inflow Concentration and Retention (Green Cross). Source: Asarian et al. 2010.**

Due to a lack of available data, the Yurok Tribe analysis does not consider other possible factors that may decrease nutrients upstream of Copco 1 Reservoir under the Proposed Action, such as TMDL implementation or elimination of peaking flows from hydropower operations (Asarian et al. 2010). If reductions in nutrient concentrations do occur upstream of Copco 1, then less nutrients would be available for removal in the reservoirs and dam removal would likely result in smaller long-term increases in nutrient concentration than predicted by the Yurok Tribe analysis (Asarian et al. 2010) analysis.

Klamath TMDL modeling efforts include an assumption of compliance with upstream TP and TN load allocations for both Oregon and California (NCRWQCB 2010a). Results are in general agreement with PacifiCorp (FERC 2007) and Yurok Tribe (Asarian et al. 2010) analyses regarding dam removal effects on nutrients, with very small annual increases in TP (0.01–0.015 mg/L) and relatively larger annual increases in TN (0.1–0.125 mg/L) immediately downstream of Iron Gate Dam (RM 190.1). Increases in nutrients would diminish with distance downstream. Note that while following the same relative trend as the Yurok Tribe analysis, the absolute increases predicted by TMDL model are much lower (e.g., 0.1–0.125 mg/L TN increase for the TMDL model vs. 0.1–0.5 mg/L TN increase for the Yurok Tribe analysis).

Continuing increased variability in TP and TN are predicted by the Klamath TMDL model (see Appendix D) during summer months, presumably due to nutrient uptake dynamics by periphyton and macrophytes. The TMDL model does not include denitrification as a possible nitrogen removal term in riverine segments (Tetra Tech 2009), meaning that TN concentrations under the Proposed Action (but also the No Action/No Project Alternative) may be slightly overpredicted. Corresponding small differences in ortho-phosphorus, nitrate, and ammonium concentrations under the Proposed Action (as compared with the No Action/No Project Alternative, including TMDL compliance) are predicted by the model; however, within the uncertainty of future nutrient dynamics these differences are not clearly discernable as increases or decreases. TMDL model results indicate that while resulting TP levels would meet the existing Hoopa Valley Tribe numeric water quality objective (0.035 mg/L TP) at the Hoopa reach (≈RM 45–46) of the Klamath River, TN levels would continue to be in excess of the existing objective (0.2 mg/L TN) (NCRWQCB 2010a).

Despite the overall increases in absolute nutrient concentrations anticipated under the Proposed Action, the relatively greater increases in TN may not result in significant biostimulatory effects on primary productivity (i.e., periphyton growth). Existing data indicate that the Klamath River is generally N-limited (TN:TP <10), with some periods of co-limitation by N and P (see Section 3.2.3.4 and Appendix C, Section C.3.2.1). However, concentrations of both nutrients are high enough in the river from Iron Gate Dam (RM 190.1) to approximately Seiad Valley (RM 129.4) (and potentially further downstream) that nutrients are not likely to be limiting primary productivity (i.e., periphyton growth) in this portion of the Klamath River (FERC 2007, HVTEPA 2008, Asarian et al. 2010). In addition, N-fixing species dominate the periphyton communities in the lower reaches of the Klamath River where inorganic nitrogen concentrations are low (Asarian et al. 2010). Since these species can fix their own nitrogen from the

atmosphere, increases in TN due to dam removal may not significantly increase their growth (see also Section 3.4, Algae), particularly if overall TN increases are less than those predicted by existing models due to implementation of TMDLs and general nutrient reductions in the Klamath Basin. **Under the *Proposed Action*, the long-term (2–50 years following dam removal) increase in nutrients in the lower Klamath River and the Klamath Estuary would be a less-than-significant impact.**

#### **3.2.4.3.2.4 Dissolved Oxygen**

##### Upper Klamath Basin

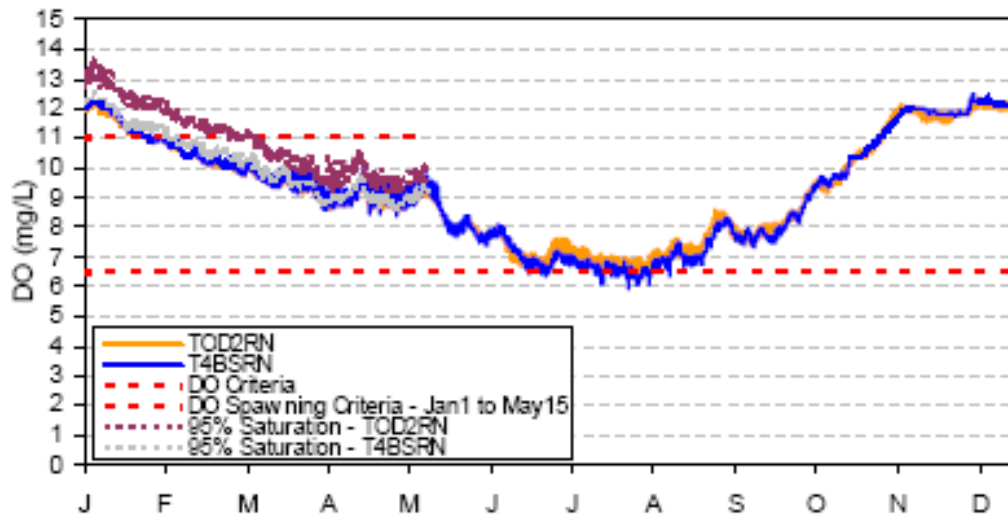
*Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) increases in oxygen demand and reductions in dissolved oxygen in the Hydroelectric Reach downstream of J.C. Boyle Reservoir.* While modeled oxygen demand is not available downstream of J.C. Boyle Reservoir, model results are available downstream of Iron Gate Dam as a function of SSC (see Section 3.2.4.3.2.4, Lower Klamath Basin) and can be applied to the Hydroelectric Reach downstream of J.C. Boyle Reservoir. This assumes as a worst case scenario that the effects of sediment release on short-term oxygen demand (and reductions in dissolved oxygen) in the Hydroelectric Reach downstream of J.C. Boyle Dam would be the same as those for the lower Klamath River. This is a conservative assumption because peak SSCs downstream of J.C. Boyle Reservoir would be much lower and of shorter duration (i.e., 2,000–3,000 mg/L occurring within 1–2 months of reservoir drawdown) than those predicted downstream of Iron Gate Dam (i.e., 7,000–14,000 mg/L occurring within 2–3 months of reservoir drawdown) (see Section 3.2.4.3.2.2 and Figures 3.2-8 through 3.2-10). Like the effect determination for the Klamath River downstream of Iron Gate Dam, this would be a significant impact (see detailed analysis for Lower Klamath Basin, below).

**Under the *Proposed Action*, the short-term (<2 years following dam removal) decrease in dissolved oxygen concentrations would be a significant impact on the riverine reaches of the Klamath River downstream of J.C. Boyle Dam to the Oregon-California state line.**

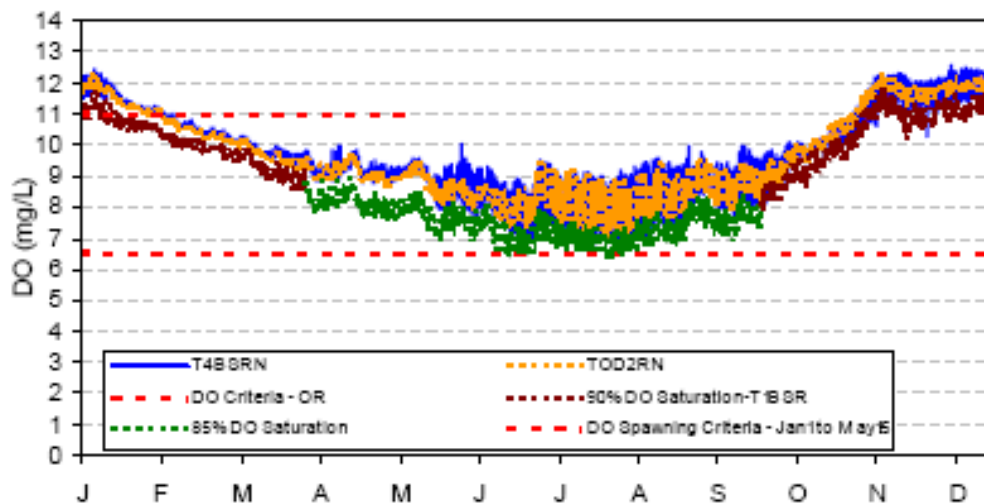
*Removal of the Four Facilities under the Proposed Action could cause long-term (2–50 years following dam removal) increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the Hydroelectric Reach.* Modeling conducted for development of the Oregon and California Klamath River TMDLs indicates that under the Proposed Action (similar to the TMDL TOD2RN scenario), dissolved oxygen concentrations in the Hydroelectric Reach downstream of J.C. Boyle Dam and at the Oregon-California state line would be slightly greater during July through October than those under the No Action/No Project (similar to the TMDL T4BSRN scenario), due to the removal of J.C. Boyle Reservoir (see Figure 3.2-16 and Figure 3.2-17; NCRWQCB 2010a). The same pattern is predicted for 30-day mean minimum and 7-day mean minimum dissolved oxygen criteria. The Klamath TMDL model (see Appendix D) also predicts that daily fluctuations in dissolved oxygen at these locations during this same period may be greater under the Proposed Action (TCD2RN) than the No Action/No Project Alternative (T4BSRN), a condition potentially linked to greater periphyton biomass and associated daily photosynthetic swings in oxygen production in the free-



flowing river. Modeling predictions are generally in compliance with the Oregon water quality objectives for supporting warm water (5.5 mg/L) and cool water (6.5 mg/L) fish beneficial uses, where lower dissolved oxygen concentrations in June–August would meet the Oregon narrative natural conditions criterion that supersedes the numeric objectives for the cold water beneficial use (8.0 mg/L). The same would occur for predicted concentrations in mid-February–May as related to the spawning (11 mg/L) beneficial use (Figure 3.2-16 and Figure 3.2-17; NCRWQCB 2010a).



**Figure 3.2-16. Predicted Dissolved Oxygen Downstream of J.C. Boyle Dam (RM 224.7 to 228.3) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**



**Figure 3.2-17. Predicted Dissolved Oxygen at the Oregon-California State Line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**

For the free-flowing reaches of the river replacing the reservoirs, long-term dissolved oxygen levels would differ substantially from the super-saturation (i.e., >100% saturation) that currently occurs in surface waters and the hypolimnetic oxygen depletion in that occurs in bottom waters of Copco 1 and Iron Gate Reservoirs during the April/May through October/November period (see Section 3.2.3.5). Dissolved oxygen in the free-flowing reaches of the river replacing the reservoirs would not exhibit such extremes, instead possessing the riverine signal described above. Relative changes in dissolved oxygen under the Proposed Action would be less pronounced in the reach currently occupied by J.C. Boyle Reservoir, due to the lack of persistent thermal stratification in that reservoir.

The increased daily fluctuations in dissolved oxygen indicated by the Klamath TMDL modeling efforts are not entirely certain; the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities is unknown because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are uncertain (see Section 3.2.1.1).

**Under the *Proposed Action*, the long-term (2–50 years following dam removal) increase in summer and fall dissolved oxygen concentrations in the Hydroelectric Reach would be beneficial.**

#### Lower Klamath Basin

*Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) increases in oxygen demand (Immediate Oxygen Demand [IOD] and Biological Oxygen Demand [BOD]) and reductions in dissolved oxygen in the lower Klamath River, the Klamath Estuary and the marine nearshore environment.* Under the Proposed Action, high SSCs are expected in the middle and lower Klamath River immediately following dam removal (see Alternative 2 – Full Facilities Removal of Four Dams – Suspended Sediments). The high fraction of organic carbon present in the reservoir sediments (see Section 3.2.3.1) allows for the possibility of oxygen demand generated by microbial oxidation of organic matter exposed to the water column from deep within the sediment profile and mobilized during dam removal.

Based on results from a dissolved oxygen spreadsheet model (see Section 3.2.4.1), IOD downstream of Iron Gate Dam would be 0–8.6 mg/L and BOD would be 0.3–43.8 mg/L for all water year types considered (i.e., wet, median, dry) and for all six months following drawdown (see Table 3.2-12). The highest predicted oxygen demand levels (i.e., IOD and BOD) would occur during the first four to eight weeks following drawdown of Copco 1 and Iron Gate Reservoirs (i.e., in February 2020) corresponding to the peak SSCs in the river (see above section on suspended sediments). Despite the relatively high predicted IOD and BOD values, dissolved oxygen concentrations downstream of Iron Gate Dam would generally remain greater than 5 mg/L (see Table 3.2-13), the minimum acceptable dissolved oxygen concentration for salmonids. Exceptions include predicted concentrations in February 2020 for median (WY1976) and

typical dry year (WY2001) hydrologic conditions, which exhibit minimum values of 3.5 mg/L and 1.3 mg/L, respectively.

**Table 3.2-12. Estimated Short-term Immediate Oxygen Demand (IOD) and Biochemical Oxygen Demand (BOD) by Month for Modeled Flow and SSCs Immediately Downstream of Iron Gate Dam Under the Proposed Action.**

Year	Avg. Monthly Temperature (deg C) <sup>1</sup>	80% Dissolved Oxygen <sup>2</sup>	Flow (cfs) <sup>3</sup>	Flow (cms)	SSC (mg/L) <sup>4</sup>	IOD (mg/L)	BOD (mg/L)
<b>Typical Wet Hydrology (WY 1984 Conditions Assumed)</b>							
11/30/2019	9.9	7.29	3,343	95	444	0.3	1.6
12/1/2019	5.0	9.40	7,139	202	430	0.3	1.5
1/21/2020	3.7	9.73	8,675	246	1,962	1.2	6.9
2/15/2020	4.4	9.55	3,949	112	7,116	4.5	25.1
3/1/2020	6.7	9.00	4,753	135	593	0.4	2.1
4/15/2020	8.4	8.63	4,374	124	939	0.6	3.3
<b>Median Hydrology (WY 1976 Conditions Assumed)</b>							
11/12/2019	9.9	7.29	2,074	59	96.2	0.1	0.3
12/12/2019	5.0	9.40	2,156	61	202.5	0.1	0.7
1/22/2020	3.7	9.73	6,533	185	2,593.5	1.6	9.1
2/14/2020	4.4	9.55	2,933	83	9,893.2	6.2	34.8
3/1/2020	6.7	9.00	3,016	85	1,461.2	0.9	5.1
4/7/2020	8.4	8.63	2,657	75	509.3	0.3	1.8
<b>Typical Dry Hydrology (WY 2001 Conditions Assumed)</b>							
11/19/2019	9.9	7.29	1,141	32	79.1	0.0	0.3
12/23/2019	5.0	9.40	1,284	36	122.2	0.1	0.4
1/17/2020	3.7	9.73	4,245	120	3,513.7	2.2	12.4
2/16/2020	4.4	9.55	1,040	29	13,573.5	8.6	47.8
3/2/2020	6.7	9.00	1,344	38	2,420.7	1.5	8.5
4/5/2020	8.4	8.63	1,150	33	551.1	0.3	1.9

Source: Stillwater Sciences 2011

<sup>1</sup> Raw daily water temperature data for 2009 from <http://www.pacificorp.com/es/hydro/hl/kr.html#> (PacifiCorp 2009). Monthly summary data also presented in Table 3.2-12.

<sup>2</sup> Initial dissolved oxygen downstream of Iron Gate Dam calculated for 80% saturation using average monthly water temperature, salinity = 0 ppt, and elevation = 707 m (2,320 ft). An initial dissolved oxygen at 70% saturation was used for the November model runs based on 2009 conditions (Appendix C, Table C-7).

<sup>3</sup> Predicted daily flow values from Reclamation hydrologic model output (Greimann et al. 2011). Daily flow values correspond to the peak suspended sediment concentration (SSC) for each month.

<sup>4</sup> Predicted peak suspended sediment concentration (SSC) by month from Reclamation model output under the Proposed Action (Greimann et al. 2011).

**Table 3.2-13. Estimated Location of Minimum Dissolved Oxygen and Location at which Dissolved Oxygen Would Return to 5 mg/L Downstream of Iron Gate Dam Due to High Short-term SSCs Under the Proposed Action.**

Date	Boundary Conditions at Iron Gate Dam			Spreadsheet Model Output		
	Initial Dissolved Oxygen (at 80% Saturation) <sup>1</sup>	IOD	BOD	Minimum Dissolved Oxygen	Location of Minimum Dissolved Oxygen	Location at which Dissolved Oxygen Returns to 5 mg/L <sup>2</sup>
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	RM	RM
<b>Typical Wet Hydrology (WY 1984 Conditions Assumed)</b>						
11/30/2019	7.29	0.3	1.6	7.10	189.5	190.1
12/1/2019	9.40	0.3	1.5	9.18	188.9	190.1
1/21/2020	9.73	1.2	6.9	8.56	188.2	190.1
2/15/2020	9.55	4.5	25.1	5.21	188.9	190.1
3/1/2020	9.00	0.4	2.1	8.70	188.9	190.1
4/15/2020	8.63	0.6	3.3	8.11	188.9	190.1
<b>Median Hydrology (WY 1976 Conditions Assumed)</b>						
11/12/2019	7.29	0.1	0.3	7.29	190.1	190.1
12/12/2019	9.40	0.1	0.7	9.34	189.5	190.1
1/22/2020	9.73	1.6	9.1	8.18	188.2	190.1
2/14/2020	9.55	6.2	34.8	3.49	188.9	175.2
3/1/2020	9.00	0.9	5.1	8.19	188.9	190.1
4/7/2020	8.63	0.3	1.8	8.38	189.5	190.1
<b>Typical Dry Hydrology (WY 2001 Conditions Assumed)</b>						
11/19/2019	7.29	0.0	0.3	7.29	190.1	190.1
12/23/2019	9.40	0.1	0.4	9.40	190.1	190.1
1/17/2020	9.73	2.2	12.4	7.62	188.9	190.1
2/16/2020	9.55	8.6	47.8	1.33	189.5	177.1
3/2/2020	9.00	1.5	8.5	7.62	189.5	190.1
4/5/2020	8.63	0.3	1.9	8.39	189.5	190.1

Source: Stillwater Sciences 2011.

<sup>1</sup> Initial dissolved oxygen downstream of Iron Gate Dam calculated for 80% saturation using average monthly water temperature, salinity = 0 ppt, and elevation = 707 m (2,320 ft). An initial dissolved oxygen at 70% saturation was used for the November model runs. See average monthly dissolved oxygen (% saturation) for 2009 in Appendix C, Table C-7. Raw daily water temperature data from <http://www.pacificorp.com/es/hydro/hl/kr.html#> (PacifiCorp 2009).

<sup>2</sup> Minimum acceptable dissolved oxygen concentration for salmonids.

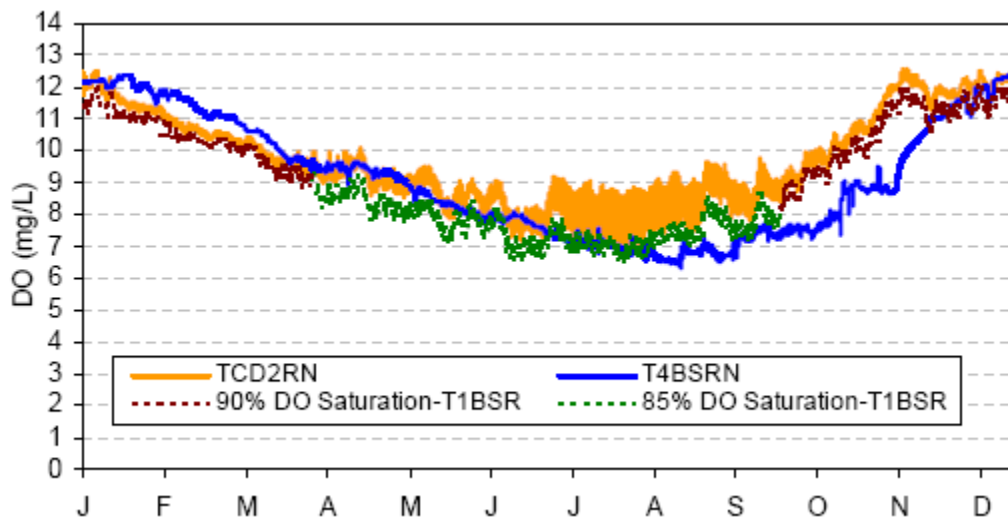
For all water year types (wet, median, dry), the predicted dissolved oxygen minimum values would occur by approximately RM 188–190 ( $\approx$  1–3 km downstream of Iron Gate Dam) and would return to at least 5 mg/L by approximately RM 175–177 (within 20–25 km of the dam), or near the confluence with the Shasta River (RM 176.7) (see Table 3.2-13). The North Coast Basin Plan water quality objective for dissolved oxygen is expressed as percent saturation; at 90 percent saturation, the water quality objective for

November through April, assuming average February (2009) water temperatures, would be 9.6–10.6 mg/l (see Table 3.2-5). Based on the spreadsheet model results, recovery to the North Coast Basin Plan water quality objective of 90 percent saturation would occur generally within the reach from Seiad Valley (RM 129.4) to the mainstem confluence with Clear Creek (see Figure 3.2-1 for location of Clear Creek), or within a distance of 100–150 km (62–93 mi) downstream of the Hydroelectric Reach, for all water year types considered (i.e., wet, median, dry). Thus, model results indicate that short-term (<2 years following dam removal) effects on dissolved oxygen would resolve well upstream of the Klamath Estuary and the Proposed Action would not affect dissolved oxygen in the estuary or the marine nearshore environment.

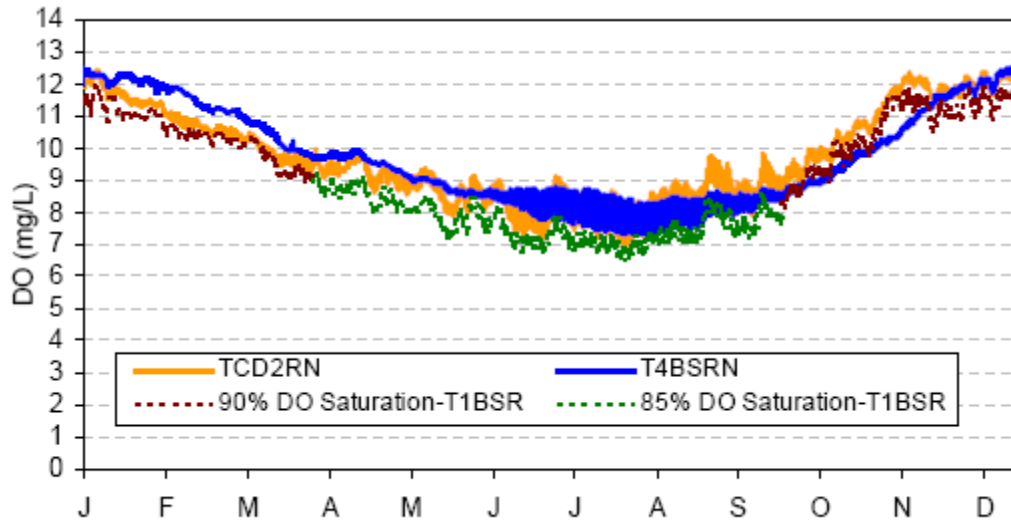
While predicted short-term increases in oxygen demand under the Proposed Action generally result in dissolved oxygen concentrations above the minimum acceptable level (5 mg/L) for salmonids, exceptions to this would occur four to eight weeks following drawdown of J.C. Boyle and Iron Gate reservoirs (i.e., in February 2020), when dissolved oxygen would remain below 5 mg/L from Iron Gate Dam to near the confluence with the Shasta River (RM 176.7), or for a distance approximately 20–25 km downstream of the dam. Recovery to the North Coast Basin Plan water quality objective of 90 percent saturation (i.e., 10–11 mg/L) would occur within a distance of 100–150 km (62–93 mi) downstream of Iron Gate Dam, or generally in the reach from Seiad Valley to the mainstem confluence with Clear Creek, and would therefore not effect dissolved oxygen in the estuary or the nearshore environment. Since the estimated reductions in dissolved oxygen described above would occur as a result of high short-term SSCs following dam removal, they would not extend to the long-term (2-50 years following dam removal). **Under the Proposed Action, the short-term (<2 years following dam removal) decrease in dissolved oxygen concentrations would be a significant impact on the lower Klamath River from Iron Gate dam possibly to Clear Creek, but would not affect dissolved oxygen in the Klamath Estuary or the marine nearshore environment.**

*Removal of the Four Facilities under the Proposed Action could cause long-term (2-50 years following dam removal) overall increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the lower Klamath River, particularly for the reach immediately downstream of Iron Gate Dam.* KRWQM (see Section 3.2.1.1 for model background) results using 2001–2004 data indicate that substantial improvements in long-term dissolved oxygen may occur immediately downstream of Iron Gate Dam if the Four Facilities are removed, with increases of 3 to 4 mg/L possible during summer and late fall (PacifiCorp 2004b). KRWQM output also predicts greater daily variations in dissolved oxygen concentrations downstream of Iron Gate Dam to the Trinity River confluence (RM 42.5) in the absence of the KHP dams, based upon the assumption that periphyton growth would occur in this reach if the dams were removed and would increase daily dissolved oxygen fluctuations. However, the KRWQM does not include nutrient retention in the mainstem river downstream of Iron Gate Dam and assumes relatively high nutrient contributions from tributaries (Asarian and Kann 2006a), which could amplify model predicted daily variations in dissolved oxygen due to periphyton growth.

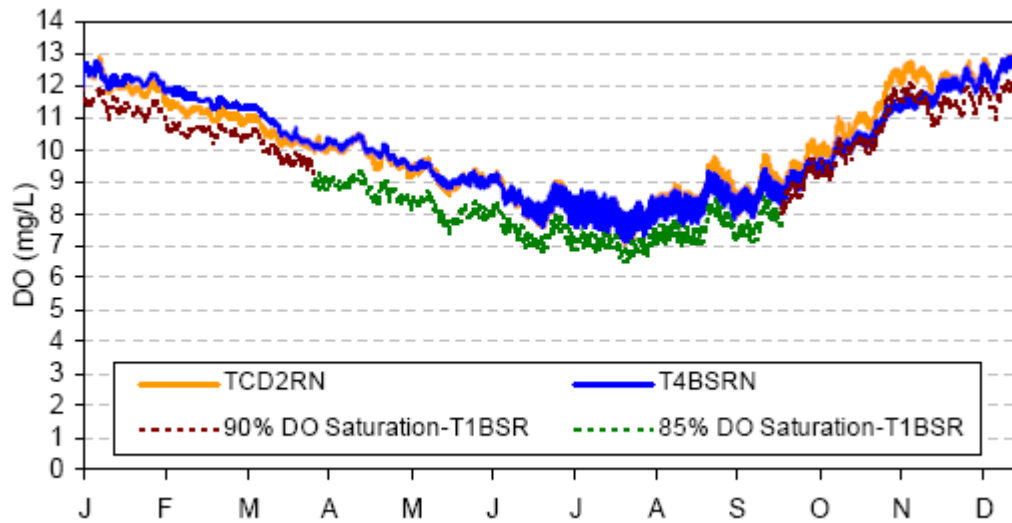
The Klamath TMDL model (see Appendix D) also indicates that under the Proposed Action (similar to the TMDL TCD2RN scenario), dissolved oxygen concentrations immediately downstream of Iron Gate Dam during July through November would be greater than those under the No Action/No Project (similar to the TMDL T4BSRN scenario), due to the lack of stratification and oxygen depletion in bottom waters in the upstream reservoirs as compared with a free-flowing river condition (see Figure 3.2-18 to Figure 3.2-21; NCRWQCB 2010a). The model also predicts that daily fluctuations in dissolved oxygen at this location during this same period would be greater under the Proposed Action (TCD2RN) than the No Action/No Project Alternative (T4BSRN) (Figure 3.2-18), a condition potentially linked to periphyton establishment in the free-flowing reaches of the river that are currently occupied by reservoirs and associated photosynthetic swings in oxygen production. The Klamath TMDL model indicates consistent compliance with the California North Coast Basin Plan water quality objective of 85 percent saturation. Results also indicate that while minimum values may occasionally dip below the current Hoopa Valley Tribe minimum water quality objective (8 mg/L), they would not fall below the 90 percent saturation objective awaiting approval by USEPA (see Table 3.2-6). Winter time (January–March) dissolved oxygen concentrations would be slightly lower under the Proposed Action, but would not fall below Basin Plan minimum criteria for the winter season (90 percent saturation; see Table 3.2-4). Differences in long-term dissolved oxygen concentrations between the Proposed Action and the No Action/No Project Alternative diminish with distance downstream of Iron Gate Dam, with similar or the same predicted dissolved oxygen concentrations and similar magnitude and duration of daily fluctuations by Seiad Valley (RM 129.4) and no differences by the confluence with the Trinity River (RM 42.5) (see Figure 3.2-18 to Figure 3.2-21).



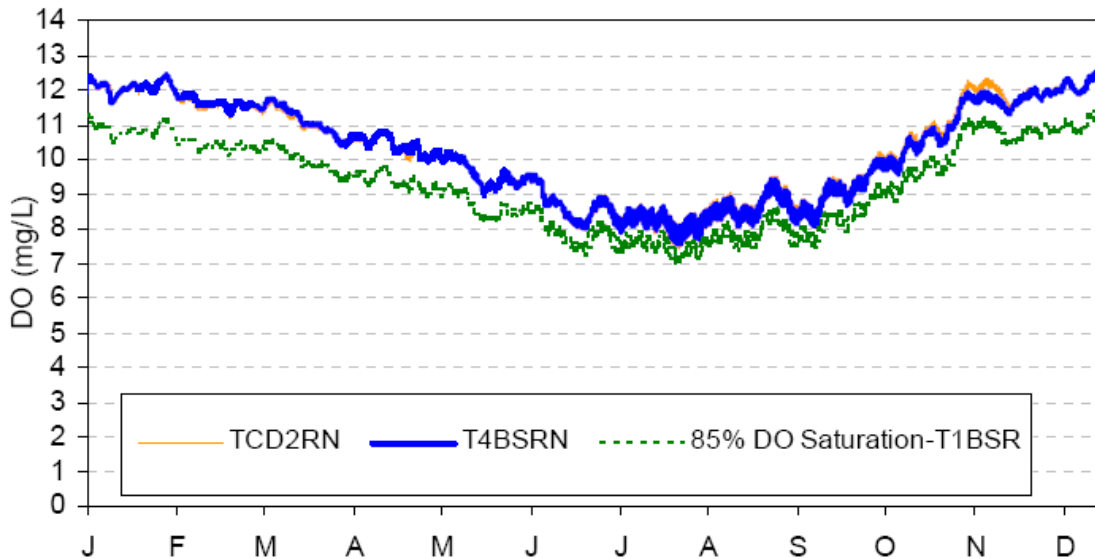
**Figure 3.2-18. Predicted Dissolved Oxygen Downstream of Iron Gate Dam (RM 190.1) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**



**Figure 3.2-19. Predicted Dissolved Oxygen Downstream of the Mainstem Confluence with the Shasta River (RM 176.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**



**Figure 3.2-20. Predicted Dissolved Oxygen at Seiad Valley (RM 129.4) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**



**Figure 3.2-21. Predicted Dissolved Oxygen Just Upstream of the Confluence with the Trinity River (RM 42.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**

The increased daily fluctuations in dissolved oxygen immediately downstream of Iron Gate Dam predicted by the PacifiCorp and Klamath TMDL modeling efforts are not entirely certain; the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities is unknown because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are uncertain (see Section 3.4, Algae). Therefore, overall, the removal of the Four Facilities under the Proposed Action would cause long-term increases in summer and fall dissolved oxygen in the lower Klamath River immediately downstream of Iron Gate Dam, along with potentially increasing daily variability. Effects would diminish with distance downstream of Iron Gate Dam, such that there would be no measurable effects on dissolved oxygen by the confluence with the Trinity River. **Under the *Proposed Action*, the long-term (2–50 years following dam removal) increases in summer and fall dissolved oxygen concentrations immediately downstream of Iron Gate Dam would be beneficial.**

#### 3.2.4.3.2.5 pH

##### Upper Klamath Basin

*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decreases in summertime pH in the Hydroelectric Reach.* Modeling of pH conducted for development of the Oregon and California Klamath River TMDLs (Kirk et al. 2010, NCRWQCB 2010a) provides information applicable to the assessment of long-term effects of the Proposed Action on pH in the Upper Klamath Basin.

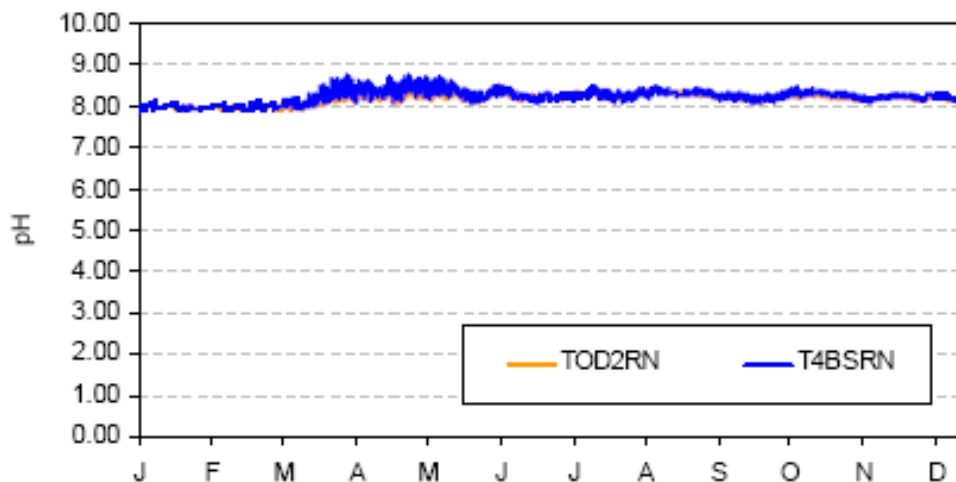


While reaches upstream of the Hydroelectric Reach (i.e., from RM 231 to RM 251, Upper Klamath Lake, Agency Lake, and the Sprague River) are included on Oregon's 303(d) list for pH, the hydropower reach itself is not currently identified as being impaired (see Table 3.2-8). Further, Klamath TMDL model results indicate that under the Proposed Action (similar to the TMDL TOD2RN scenario), pH in the Hydroelectric Reach immediately downstream of J.C. Boyle Dam would be the same as pH levels modeled under the No Action/No Project (similar to the TMDL T4BSRN scenario), with the potential for some decreases in minimum daily values (see Figure 3.2-22). At the Oregon-California state line, pH levels under the Proposed Action would be roughly the same as those predicted under the No Action/No Project, but with less daily variability during spring (March–May) and fall (October–November) (see Figure 3.2-23) due to the removal of reservoir habitat for suspended algal growth. Similar to dissolved oxygen (see above section), the changes in daily fluctuations for pH indicated by the Klamath TMDL modeling efforts are not entirely certain; the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities (including Keno Impoundment and Lake Ewauna as an assumption of the TOD2RN model [Appendix D]) is unknown because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are uncertain (see Section 3.2.1.1). Periphyton growth may increase in the Hydroelectric Reach under the Proposed Action and increase daily variability in pH.

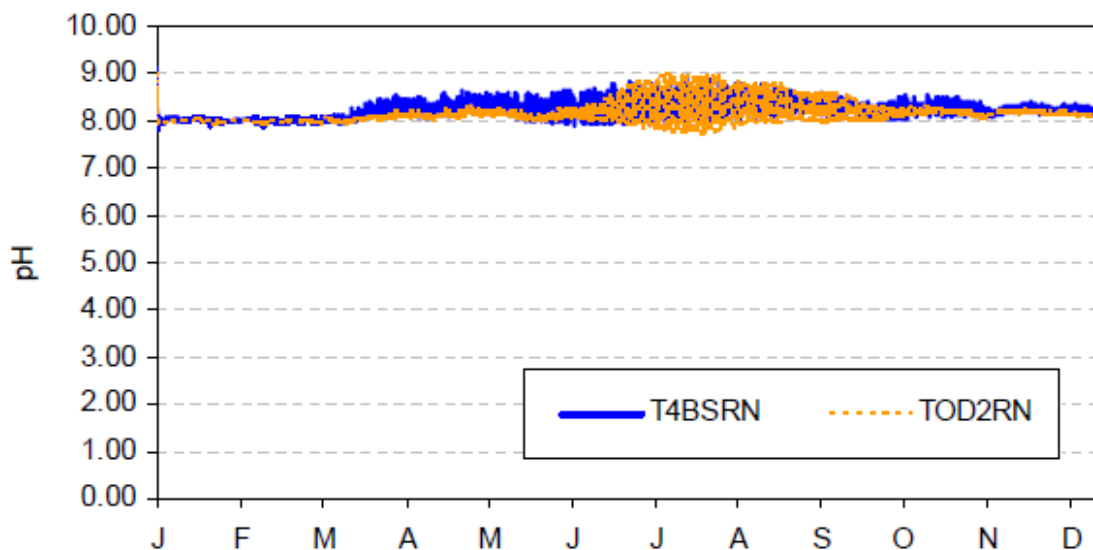
However, based on TMDL model results, pH under the Proposed Action in the Hydroelectric Reach upstream of the Oregon-California state line would consistently meet the Oregon water quality objective of 9.0 units for support of beneficial uses (based on Klamath TMDL model results).

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020, pH effects of the Proposed Action in the Hydroelectric Reach would occur, either partially or fully, within the first 1 to 2 years following dam removal and be a short-term effect as well as a long-term effect. The exception to this is the potential for increased daily variability in pH due to increases in periphyton growth in the Hydroelectric Reach. Increased daily variability due to periphyton growth likely would not occur in the short-term because high SSCs and scour in the river 1-2 years following dam removal would limit the establishment of periphyton in the free-flowing river reaches.

**Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decrease in high summertime daily pH fluctuations in the Hydroelectric Reach would be beneficial.**



**Figure 3.2-22. Predicted pH Downstream of J.C. Boyle Reservoir (RM 224.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**



**Figure 3.2-23. Predicted pH at the Oregon-California State Line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**

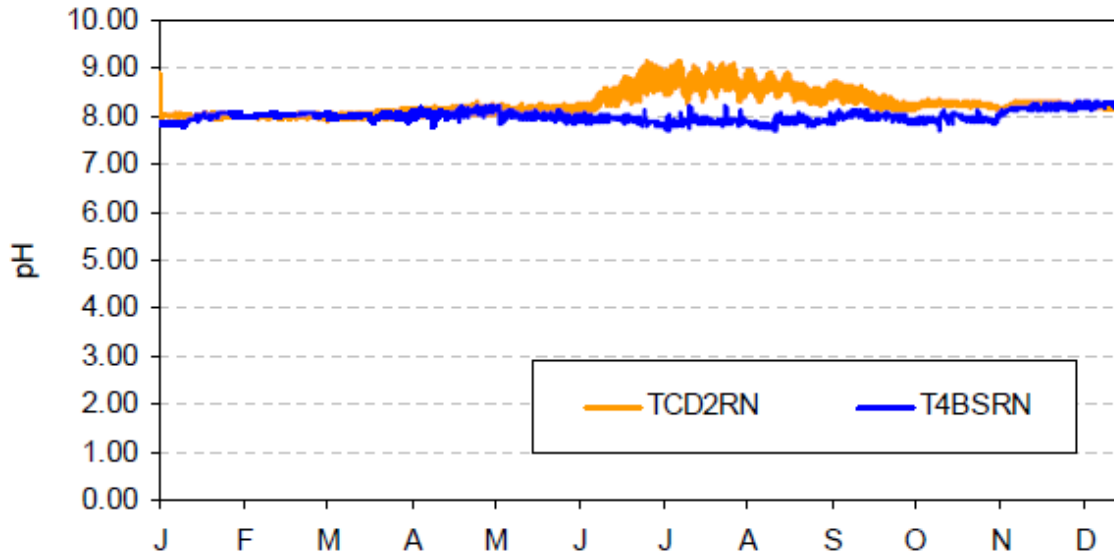
### Lower Klamath Basin

*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in long-term (2–50 years following dam removal) summertime increases in pH in the Lower Klamath River, the Klamath Estuary, and the marine nearshore environment.* Modeling of pH conducted for the development of the California Klamath River TMDLs provides information applicable to the assessment of long-term effects of the Proposed Action on pH in the Lower Klamath Basin. In general, results from the Klamath TMDL model (see Appendix D for a summary of model attributes) indicate that spikes in photosynthetic activity in the relatively low alkalinity (typically <100 mg/L; PacifiCorp [2004b], Karuk Tribe of California [2010]) water of the Klamath River, coupled with high air temperatures and high levels of biostimulatory nutrients during the late-summer and early-fall months, would result in large daily variation in pH and generally high pH levels in the Klamath River downstream of Iron Gate Dam (see Figure 3.2-24). This may result in instantaneously exceeding the North Coast Basin Plan water quality objective maximum pH value of 8.5 (see Table 3.2-4), which may be stressful to fish and other aquatic life and adversely affect beneficial uses.

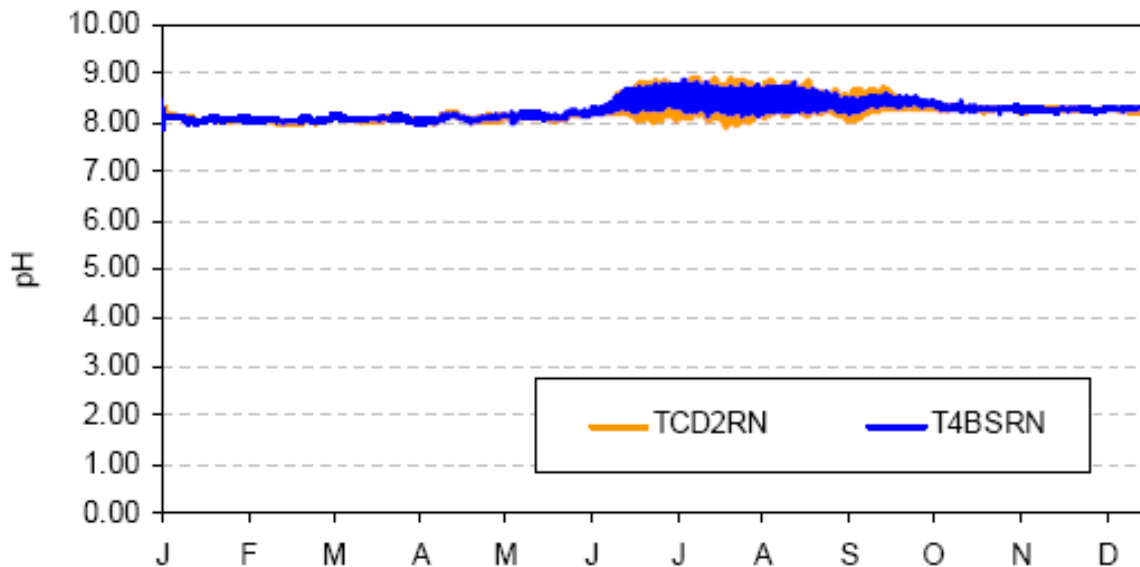
Predicted differences in pH between the Proposed Action and No Action/No Project Alternative decrease in magnitude with distance downstream of Iron Gate Dam, and would no longer be evident by the Scott River confluence (RM 143.0) (see Figure 3.2-25). The Hoopa Valley Tribe water quality objective for pH (7.0-8.5) (see Table 3.2-6) is met at all times under the Proposed Action (similar to the TMDL TCD2RN scenario) for the Klamath River at the reach of Hoopa jurisdiction (≈45–46). Therefore, under the Proposed Action, pH would not be affected in the lower river downstream of the Scott River, including the Klamath Estuary and the marine nearshore environment.

Although the California Klamath River TMDL model predicts long-term increases in pH due to enhanced periphyton growth and increased rates of photosynthesis immediately downstream of Iron Gate Dam, this condition may be counteracted by increased scour at this location under the Proposed Action (see Section 3.4, Algae). Given the uncertainty in the model output from Iron Gate Dam to the Shasta River, and given the localized and instantaneous nature of the predicted high pH levels during summer months, these long-term pH increases would be less than significant.

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020, pH effects of the Proposed Action in the Hydroelectric Reach would occur, either partially or fully, within the first 1 to 2 years following dam removal and be a short-term effect as well as a long-term effect. The exception to this is the potential for increases in pH due to increases in periphyton growth in the Hydroelectric Reach. The latter likely would not occur in the short-term because high SSCs and scour in the river 1-2 years following dam removal would limit the establishment of periphyton in the free-flowing river reaches.



**Figure 3.2-24. Predicted Klamath River pH Immediately Downstream of Iron Gate Dam for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**



**Figure 3.2.25. Predicted Klamath River pH upstream of the Scott River (RM 143.0) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**

**Long-term summertime increases in pH under the *Proposed Action* would be less than significant for the reach from Iron Gate Dam to the Scott River (RM 143). There would be no change from existing conditions on pH in the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) for the Klamath River just downstream of Seiad Valley, the Klamath Estuary, and the marine nearshore environment.**

#### **3.2.4.3.2.6 Chlorophyll-a and Algal Toxins**

##### Upper Klamath Basin

*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could cause short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decreases in levels of chlorophyll-a and algal toxins in the Hydroelectric Reach.* Despite the slightly increased total nutrient concentrations anticipated under the Proposed Action in the Hydroelectric Reach (see Alternative 2 – Full Facilities Removal of Four Dams – Nutrients), elimination of the lacustrine (reservoir) environment that currently supports growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* would result in decreases in high seasonal concentrations of chlorophyll-a (>10 µg/L) and periodically high levels of algal toxins (> 8 µg/L microcystin) generated by suspended blue-green algae. While algal toxins and chlorophyll-a produced in Upper Klamath Lake may still be transported into the Hydroelectric Reach at levels exceeding water quality objectives for Oregon and California, additional *in situ* production of the toxins and chlorophyll-a associated with suspended algae would be significantly less likely to occur in the free-flowing river under the Proposed Action.

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020 (i.e., the beginning of the growth season), elimination of the lacustrine (reservoir) environment under the Proposed Action would occur, either partially or fully, within the first 1 to 2 years following dam removal. Therefore, this would be a short-term effect on chlorophyll-a and algal toxins in the Hydroelectric Reach as well as a long-term effect.

**Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decrease in production of algal toxins and chlorophyll-a in the Hydroelectric Reach would be beneficial.**

##### Lower Klamath Basin

*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could cause short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decreases in levels of chlorophyll-a and algal toxins transported into the lower Klamath River and the Klamath Estuary.* In addition to the decreases in high seasonal concentrations of chlorophyll-a (>10 µg/L) and periodically high levels of algal toxins (>8 µg/L microcystin) generated by nuisance algal species that are described for the Hydroelectric Reach (see Section 3.2.4.3.2.6, Upper Klamath Basin), growth of *M. aeruginosa* in reaches of the Klamath

River downstream of Iron Gate Dam would be reduced in the absence of significant reservoir blooms. While algal toxins and chlorophyll-*a* produced in Upper Klamath Lake (see Section 3.2.3.1) may still be transported into the Lower Klamath Basin, existing data indicate that concentrations of microcystin leaving Upper Klamath Lake have rarely, if ever, been measured at levels that exceed water quality objectives for Oregon and California. In contrast, algal production in Iron Gate and Copco Reservoirs is responsible for the observed public health exceedances occurring in the Klamath River downstream of Iron Gate Dam (see Section 3.2.3.7 and Appendix C, Section C.6). Under the Proposed Action, the *in situ* production of toxins and chlorophyll-*a* associated with suspended algae in the reservoirs would be eliminated.

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020 (i.e., the beginning of the growth season), effects of the Proposed Action on chlorophyll-*a* and algal toxins in the lower Klamath River would occur, either partially or fully, within the first 1 to 2 years following dam removal and be a short-term effect as well as a long-term effect.

**Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decreases in the production of algal toxins and chlorophyll-*a* in upstream reservoirs and subsequent transport into the lower Klamath River and the Klamath Estuary would be beneficial.**

#### **3.2.4.3.2.7 Inorganic and Organic Contaminants**

##### **Upper Klamath Basin**

*Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in concentrations of inorganic and organic contaminants and result in low-level exposure for freshwater aquatic species in the Hydroelectric Reach.* Due to the relatively small volume of the sediment deposits behind J.C. Boyle Dam (i.e., 15 percent of total volume for the Four Facilities), concentrations of suspended sediments downstream of J.C. Boyle Reservoir would be considerably less than those anticipated to occur downstream of Iron Gate Reservoir. Because the transport of contaminants would be associated with the elevated SSCs, as a conservative estimate, effects of sediment release on inorganic and organic contaminants in the Hydroelectric Reach downstream of J.C. Boyle Dam would be the same as those for the lower Klamath River. **Under the *Proposed Action*, the short-term (< 2 years following dam removal) and long-term (2–50 years following dam removal) effects of sediment release on freshwater aquatic species due to low-level exposure to sediment-associated inorganic and organic contaminants in the Hydroelectric Reach would be a less-than-significant impact.**

*The Proposed Action could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) human exposure to contaminants from contact with deposited sediments on exposed reservoir terraces and river banks following reservoir drawdown.* Potential human health risks associated with exposure to sediments deposited on exposed reservoir terraces and river banks within the Hydroelectric Reach

were evaluated using comparisons of the 2009–2010 Secretarial Determination reservoir sediment core data to USEPA residential soil screening levels, and calculation of human/mammal TEQs and comparison to ODEQ Bioaccumulation SLVs (exposure “Scenario 3” in CDM [2011]). No samples exceeded the total non-carcinogenic screening levels. Forty-seven samples exceeded the USEPA total carcinogenic screening level for arsenic or nickel, including samples from J.C. Boyle, Copco 1 and Iron Gate Reservoirs (and the Klamath Estuary, although this location is not relevant to reservoir deposits under the Proposed Action). However, these screening levels were developed assuming residential exposure patterns (a 30-year exposure duration with soil ingestion rate of 200 mg/day for children over 6 years and 100 mg/day for adults over 24 years) (USEPA 1991), which is quite conservative and the measured values are well within typical background concentrations for the Klamath Basin (arsenic may be naturally elevated in the Upper Klamath Basin [see Section 3.2.2.8, Inorganic and Organic Contaminants]). For 19 analytes measured during 2009–2010, laboratory analytical reporting limits were greater than the applicable human health screening levels, including PCBs, VOCs, and SVOCs (CDM 2011). It is not possible to directly confirm that these compounds are above or below applicable human health screening levels.

TEQs calculated for dioxin, furan, and dioxin-like PCBs were at concentrations above ODEQ Bioaccumulation SLVs for mammals in sediments from each of the reservoirs (CDM 2011). ODEQ Bioaccumulation SLVs are not applicable to water bodies in California; however, they provide a reference for comparison purposes. Although site-specific background data are lacking, TEQs are also only slightly above regional background concentrations and thus have limited potential for adverse effects for humans exposed to sediment deposits on reservoir terraces or river banks. The sources of the slightly elevated dioxin, furan, and dioxin-like PCB compounds are not known; however, sources may include atmospheric deposition, regional forest fires, and possibly burning of plastic items (CDM 2011).

Results from the 2009–2010 Secretarial Determination sediment chemistry analyses indicate that sediment deposits associated with the Proposed Action would cause no adverse effects on humans (terrestrial biota were also evaluated qualitatively, but are not discussed here) (see Figure 3.2-2). **Under the *Proposed Action*, the effects of sediment deposition on reservoir terraces and river banks on short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) human exposure to sediment-associated inorganic and organic contaminants in the Hydroelectric Reach would be a less-than-significant impact.**

*Dam deconstruction and revegetation (i.e., hydroseeding) activities could cause short-term (<2 years following dam removal) increases in inorganic and organic contaminants from hazardous materials associated with construction and revegetation (i.e., hydroseeding) equipment in the Hydroelectric Reach.* These effects would be reduced through implementation of BMPs for deconstruction and revegetation activities that would occur in or adjacent to the Klamath River. BMPs would minimize or eliminate the potential for toxic substances to enter the water. **Under the *Proposed Action*, the short-term (<2 years following dam removal) effects on inorganic and organic**

**contaminants in the Hydroelectric Reach from dam deconstruction and restoration (i.e., hydroseeding) activities would be a less-than-significant impact.**

*Under the Proposed Action, herbicide application associated with management of the reservoir footprint area could result in short-term (<2 years following dam removal) levels of organic contaminants in runoff that are toxic to aquatic biota in the Hydroelectric Reach.* Based on the reservoir area management planning currently underway, establishment of herbaceous vegetation in drained reservoir areas will be undertaken to stabilize the surface of the sediment and minimize erosion from exposed terrace surfaces following drawdown (O'Meara et al. 2010). Herbicides would be necessary during this period to control the growth of invasive plant species, with application occurring during the first year following dam removal and potentially during the second, if further treatments are necessary. Herbicide application would be required for 25 percent, 50 percent, and 75 percent of the total reservoir area for the low, most probable, and high cost restoration estimates, respectively (O'Meara et al. 2010).

The reservoir area management plan recognizes the potential water quality effects of herbicide application and calls for the use of herbicides with low soil mobility, and thus low potential to leach into groundwater or surface waters. It also calls for low use rates of herbicides and application of chemicals that pose a low toxicity risk to fish and aquatic organisms. Glyphosate is suggested in the management plan as one potential herbicide with such characteristics (O'Meara et al. 2010). To minimize use rates, spot treatments of a post-emergent herbicide such as glyphosate would be used rather than aerial application.

If glyphosate is chosen as a suitable herbicide for reservoir invasive plan management, it is recommended that glyphosate formulations containing POEA or R-11 are avoided to reduce risks to amphibians and other aquatic organisms (BLM 2010). Aquatic formulations of glyphosate (i.e., Glyphos Aquatic) are developed for use in sensitive protected environments such as habitat restoration sites and wetlands. Additionally, best management practices such as the "no rain" rule should be followed, such that glyphosate would never be applied when weather reports predict precipitation within 24 hours of application, before or after (BLM 2010). If another herbicide is chosen, it should meet the characteristics of low soil mobility and low toxicity to fish and aquatic organisms, and should be applied using BMPs such as low use rates (i.e., spot treatments), avoidance of application in the rain, avoidance of treatments during periods when fish are in life stages most sensitive to the herbicide(s) used, and adherence to appropriate buffer zones around stream channels (BLM 2010). **Under the *Proposed Action*, given implementation of applicable BMPs, the effect of herbicide application on toxicity and/or bioaccumulation in the Hydroelectric Reach during the revegetation period would be a less-than-significant impact.**



### Lower Klamath Basin

#### *Freshwater Aquatic Life Toxicity and/or Bioaccumulation*

*Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in concentrations of inorganic and organic contaminants and result in low-level exposure for freshwater aquatic species in the lower Klamath River.* Organic and inorganic contaminants have been identified in the sediment deposits currently trapped behind the dams (see Section 3.2.3.1). Under the Proposed Action, short-term (<2 years following dam removal) pathways of contaminant exposure for freshwater aquatic species include exposure during sediment transit through the Lower Klamath Basin river reaches (exposure “Scenario 2” in CDM [2011]), while long-term (2–50 years following dam removal) pathways include exposure following deposition of sediments along river beds and the estuary bottom (exposure “Scenario 4” in CDM [2011]).

As described for the No Action/No Project Alternative, existing sediment chemistry data (2004–2005) collected from 26 cores in J.C. Boyle, Copco 1, and Iron Gate Reservoirs indicate generally low levels of metals, pesticides, chlorinated acid herbicides, PCBs, VOCs, SVOCs, cyanide, and dioxins (Shannon & Wilson, Inc. 2006; see Section 3.2.3.8). Collection of additional sediment cores in 2009–2010 for the Secretarial Determination process indicates no positive exceedances of applicable screening levels indicating a low risk of toxicity to freshwater sediment-dwelling organisms in the lower Klamath River under the Proposed Action. Results from acute (10-day) sediment bioassays for two national benchmark toxicity species (see above discussion under No Action/No Project Alternative) indicate generally equal or greater survival in reservoir sediments as compared with laboratory control samples. The exception is J.C. Boyle Reservoir, which exhibited considerably lower survival for *Chironomus dilutus* in the on-thalweg sample as compared with the laboratory control (64 percent vs. 95 percent) and somewhat lower survival for the off-thalweg sample (83 percent vs. 95 percent) (CDM 2011).

Although this result suggests potential for toxicity to freshwater benthic organisms downstream of the dams, under the Proposed Action, sediments from all three reservoirs will mix as they move downstream, exposing downstream aquatic biota to an “average” sediment composition rather than a reservoir-specific composition. Further, the total volume of erodible sediments in Copco 1 and Iron Gate Reservoirs (2.7 million yd<sup>3</sup> and 2.83 million yd<sup>3</sup>, respectively; see Section 2.5.1) is considerably greater than that of J.C. Boyle Reservoir (0.94 million yd<sup>3</sup>; see Section 2.5.1), diminishing the potential influence of J.C. Boyle Reservoir sediments downstream biota exposure. Finally, fine sediments released during drawdown and dam removal will be transported by large water volumes, and are unlikely to settle along the riverbed (Greimann et al. 2011, Stillwater Sciences 2008); therefore, downstream freshwater benthic organisms are unlikely to experience the same intensity of exposure to sediment elutriate concentrations or reservoir sediments as during the bioassays themselves. Overall, the freshwater sediment bioassays indicate a low likelihood of acute toxicity to downstream benthic organisms due to sediment release under the Proposed Action.

Elutriate chemistry results indicate that before consideration of dilution, aluminum, chromium, copper, lead, and mercury are present at concentrations above fresh water quality criteria for samples from J.C. Boyle, Copco 1, and Iron Gate Reservoirs (CDM 2011). However, as described above, dilution of mobilized sediments with reservoir and river water is anticipated during drawdown and dam removal activities, with further dilution occurring downstream of Iron Gate Dam due to tributary inflows. Thus, water column toxicity due to the concentrations under the Proposed Action is unlikely (CDM 2011).

Elutriate bioassay results indicate no statistically significant reduction of mean 96-hour rainbow trout survival for exposure to samples from Copco 1 and Iron Gate Reservoirs tested at 1 percent and 10 percent elutriate treatments, but a significant reduction from Copco 1 at 100 percent elutriate treatment and from Iron Gate at 50 percent and 100 percent elutriate treatments. Of these, the 1 percent and 10 percent treatments are considered to be most representative of field conditions upon reservoir drawdown due to the expectation of substantial mixing and dilution with river water and tributary inputs (CDM 2011). For J.C. Boyle Reservoir, elutriate bioassay results indicate that no further dilution would be required to prevent water column toxicity to freshwater fish, even without considering the dilution that will take place during drawdown and dam removal (CDM 2011).

Combined, results from the 2004–2005 Shannon & Wilson, Inc. (2006) study and the 2009–2010 Secretarial Determination study (CDM 2011) indicate that in the short-term (<2 years following dam removal), one or more chemicals are present at levels with potential to cause minor or limited adverse effects on freshwater aquatic species (see Figure 3.2-2). In the long-term, one or more chemicals present, but at levels unlikely to cause adverse effects based on the lines of evidence.

**Under the *Proposed Action*, the short-term (< 2 years following dam removal) and long-term (2–50 years following dam removal) effects of sediment release, transit, and potential downstream river-bank deposition on freshwater aquatic species due to low-level exposure to sediment-associated inorganic and organic contaminants in the lower Klamath River would be a less-than-significant impact.**

*Marine Aquatic Life Toxicity and/or Bioaccumulation*

*Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in concentrations of inorganic and organic contaminants and result in low-level exposure for aquatic species in the Klamath Estuary and marine nearshore environment. Organic and inorganic contaminants have been identified in the sediment deposits currently trapped behind the dams (see Section 3.2.3.8). Under the Proposed Action, short-term pathways of contaminant exposure for marine aquatic species include short-term exposure during sediment transit through the Klamath Estuary and marine nearshore environment as well as exposure following deposition in the marine nearshore environment (exposure “Scenario 5” in CDM [2011]).*

For the 2009–2010 Secretarial Determination study, there were no positive exceedances of the applicable and available maximum marine screening levels (CDM 2011), with the exception of a small number of sediment samples from J.C. Boyle Reservoir, which exceeded the applicable marine screening level for dieldrin and 2,3,4,7,8,-PECDF (CDM 2011). As the marine screening levels are designed to be protective of direct toxicity to benthic and epibenthic organisms, corresponding to a “no adverse effects level,” the vast majority of 2009–2010 samples indicate a low risk of toxicity to sediment-dwelling organisms. Additionally, the Proposed Action would result in mixing and dilution during sediment release and transit through the Klamath River estuarine and/or marine nearshore environment, exposing downstream aquatic biota to an “average” water column concentration rather than a reservoir- or site-specific concentration. For 33 analytes, laboratory analytical reporting limits were greater than the marine screening level itself (CDM 2011). For these analytes, it is not possible to determine whether these compounds are present in reservoir sediments either above or below levels of concern.

Sediment bioassays from a single upper Klamath Estuary sample indicate greater survival (89–99 percent survival) of national benchmark toxicity species in the estuary sediment sample as compared with the laboratory control samples (81–94 percent survival) (see CDM 2011). A simple comparison between the estuary area composite acute toxicity results and the reservoir super-composite results indicates similar survival for *Chironomus dilutus* (89 percent vs. 64–94 percent, respectively) and greater survival for *Hyalella azteca* (99 percent vs. 80–94 percent, respectively). The similarity in results is suggestive that under the Proposed Action, no further acute toxicity would be anticipated in the estuarine and/or marine environment as compared with that of the reservoir sediments; however, additional toxicity testing using estuarine and marine test organisms is needed to confirm this assumption. Elutriate chemistry results (prior to consideration for mixing and dilution) do not indicate likely toxicity in the marine nearshore environment under the Proposed Action (CDM 2011).

With respect to bioaccumulation potential, there are no exceedances of applicable marine bioaccumulation screening levels (CDM 2011). Further, with the exception of four samples in J.C. Boyle Reservoir (CDM 2011), levels of other known bioaccumulative compounds did not exceed ODEQ bioaccumulation SLVs for marine fish. Note that ODEQ bioaccumulatory screening levels are not strictly applicable in the California marine offshore environment; however, they are indicative of potentially bioaccumulative compounds.

Elutriate chemistry results indicate that several chemical concentrations in elutriate exceed one or more water quality criteria for evaluation of surface water exposures for marine biota. Chemicals that exceed marine surface water criteria include those generally considered to be nontoxic (e.g., phosphorus) as well as those with substantial potential for contributing to adverse effects (e.g., copper). Exposures to suspended sediment with elevated concentrations of potentially toxic chemicals are of lower concern for marine receptors than exposures to elevated concentrations of dissolved chemicals. The chemicals with the greatest potential to cause adverse effects in elutriate (e.g., copper)

are, under field conditions associated with this exposure scenario, expected to bind to particulate matter and therefore are unlikely to contribute substantially to elevated concentrations of dissolved forms in the water column. Further, substantial dilution of river water and associated suspended sediments in the marine environment would reduce the amount of sediment suspended in the water column compared to conditions directly below Iron Gate Dam (CDM 2011).

Although not conducted specifically for estuarine or marine organisms, additional lines of evidence from the 2009–2010 Secretarial Determination study including the evaluation of elutriate toxicity bioassay results for rainbow trout, sediment toxicity bioassay results for benthic invertebrate national benchmark species, comparisons of tissue-based TRVs to chemical concentrations in laboratory-reared freshwater clams and worms exposed to field collected sediments (see prior discussion of Proposed Action potential effects on freshwater aquatic species), and comparisons of tissue-based TRVs and TEQs to chemical concentrations in field collected fish tissue (see discussion under No Action/No Project, Section 3.2.4.3.1.7), exposure to inorganic and organic compounds in sediments released from the reservoirs under the Proposed Action is unlikely to cause adverse long-term impacts on estuary and marine near shore aquatic species (see Figure 3.2-2).

**Under the *Proposed Action*, the short-term (< 2 years following dam removal) and long-term (2–50 years following dam removal) effects of sediment release, transit, and deposition on aquatic species due to low-level exposure to sediment-associated inorganic and organic contaminants in the Klamath Estuary and marine nearshore environment would be a less-than-significant impact.**

#### *Human Health*

*Sediment release associated with the Proposed Action could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) human exposure to contaminants from contact with deposited sediments on downstream river banks following reservoir drawdown.* Under the Proposed Action, potential human exposure to inorganic and organic chemicals during periods of drawdown and near-term flushing of elevated SSCs in the lower Klamath River (i.e., through ingestion of contaminants from drinking water withdrawals or dermal contact with water) is likely to be of limited occurrence and shorter duration and is not further addressed.

Short-term human exposure through fish consumption (i.e., a food web pathway) can not be assessed with the available data. Resident fish species in the reservoirs are considered unlikely to survive and populate the riverine environment following the Proposed Action (see Section 3.3, Aquatic Resources). Exposure and bioaccumulation by resident riverine species in the lower Klamath River and estuary from water and suspended sediments transported under the Proposed Action is understood to be short-term (<2 years following dam removal). Human exposure to contaminants from contact with residual sediments deposited on downstream river banks is possible and the mechanism for exposure is the same as that for potential contaminants deposited on exposed reservoir terraces and river banks in the Hydroelectric Reach (see Section 3.2.4.3.2.7, Upper Klamath Basin and Figure 3.2-2).

**Under the *Proposed Action*, the effects of sediment release on human health due to short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) exposure to sediment-associated inorganic and organic contaminants in the lower Klamath River would be a less-than-significant impact.**

*Dam deconstruction and restoration (i.e., hydroseeding) activities could cause short-term (<2 years following dam removal) increases in inorganic and organic contaminants from hazardous materials associated with construction and restoration (i.e., hydroseeding) equipment in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment. These short-term effects would be a significant impact. However, the impacts may be reduced through implementation of BMPs for deconstruction and restoration activities that would occur in or adjacent to the Klamath River. BMPs would minimize or eliminate the potential for toxic substances to enter the water during the deconstruction and revegetation period. Under the *Proposed Action*, the short-term (<2 years following dam removal) effects on inorganic and organic contaminants in the lower Klamath River and the Klamath Estuary from dam deconstruction and restoration (i.e., hydroseeding) activities would be a less-than-significant impact. There would be no change from existing conditions on the marine nearshore environment.*

#### **3.2.4.3.2.8 Keno Transfer**

*Implementation of the Keno Transfer could cause adverse water quality effects. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on water quality compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (see KHSA Section 7.5.4). Therefore, implementation of the Keno Transfer would result in no change from existing conditions.*

#### **3.2.4.3.2.9 East and West Side Facilities**

*Decommissioning the East and West Side Facilities could cause adverse water quality effects. Decommissioning of the East and West Side canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA will redirect water flows currently diverted at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there will be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. Therefore, implementation of the East and West Side Facility Decommissioning action would result in no change from existing conditions.*

#### **3.2.4.3.2.10 KBRA**

The KBRA, which is a component of the Proposed Action, encompasses several programs that could affect water quality, including:

- Phases I and II Fisheries Restoration Plans
- Fisheries Reintroduction and Management Plan

- Wood River Wetland Restoration
- Water Diversion Limitations
- Water Use Retirement Program
- Interim Flow and Lake Level Program
- Upper Klamath Lake and Keno Nutrient Reduction

*Implementation of restoration actions, programs, and/or plans presented in the KBRA would accelerate restoration actions currently underway throughout the Klamath Basin (with the exception of the Trinity Basin) including KHSa implementation (i.e., dam removal) and could affect short-term (i.e., during construction activities) and long-term water quality.* Within the KBRA, the Fisheries Program and the Water Resources Program encompass the majority of the restoration actions envisioned under the agreement (see Section 2.4.3.8). Many of the KBRA implementation actions are for fisheries restoration, reintroduction, and actions that enhance the amount and timing of water available for fish. Restoration actions include, but are not limited to, prevention of fish entrainment, rehabilitation of uplands, flood plains, riparian habitats, and stream channels, provision of fish passage, and re-introduction of fish to the Upper Klamath Basin, and instream riparian, and upslope actions that protect water quality, improve water quality and/or increase habitat complexity. KBRA elements under both the Fisheries Program and Water Resources Program are also likely to affect water quality in the basin. Some actions will affect water quality through flow augmentation, while others, including the restoration and permanent protection of riparian vegetation, are anticipated to have non-flow-related water quality effects. The following sections present a programmatic analysis of potential KBRA effects on water quality.

#### Phase I Fisheries Restoration Plan

*Implementation of the Phase I Fisheries Restoration Plan could result in long-term reductions in fine sediment inputs, reduced summer water temperatures, improved nutrient interception, and increased dissolved oxygen levels.* Several ongoing resource management actions related to water quality may be amplified under the Phase I Plan (see Section 2.4.3.8). The following sections describe the ongoing actions and types of new programs that could be implemented, and their anticipated short-term and long-term effects at a programmatic level.

#### *Floodplain Rehabilitation*

Floodplain rehabilitation work would include activities to improve or restore connections between channels and floodplains to create and maintain off-channel habitat accessible to overwintering juvenile salmonids. Floodplain rehabilitation may also include activities such as riparian planting and understory thinning to facilitate the development of mature riparian stands that would provide streamside shade and large and small wood to stream channels and floodplains. Additionally, wetland restoration and levee setback or dike removal may be used to reconnect floodplain hydrology.

In the short-term (i.e., during construction activities), these activities may involve the use of backhoe equipment to dig channels, remove/reposition levees and dikes, and conduct mechanical planting. These activities could increase suspended sediments and increase

the potential for inorganic and organic contaminants from hazardous materials associated with construction activities. In the long term, increased seasonal off-channel habitat, wetland restoration, and levee setbacks, may reduce fine sediment deposition in the main channel by allowing sediments and associated nutrients to deposit on floodplains and in wetlands during high flows. Increased stream shading would decrease summer temperatures and increase dissolved oxygen concentrations.

#### *Wetland and Aquatic Habitat Restoration*

Upstream of Upper Klamath Lake, activities would include the purchase of restoration easements and the creation of grass banks to facilitate habitat improvement and landowner economic stability. In the short term (i.e., during construction activities), these activities may involve the use of hydroseeding to conduct grass planting. In the long term, restoration easements may reduce fine sediment deposition in the main channel by allowing sediments and associated nutrients to deposit along streambanks and wetlands protected by easements and grass banks during high flows.

#### *Woody Debris Placement*

In-stream and streambank large woody debris placement may include both mobile wood (i.e., unanchored) and complex stationary (i.e., anchored) structures and may be used to create off-channel fish habitat or provide cover in deeper pools. In the short term, these activities may involve the use of construction equipment to place large wood in the stream channel or along banks.

#### *Fish Passage Correction*

Correction of fish passage issues throughout the Klamath Basin may include culvert upgrades or replacement to meet current fish passage standards and correction of other fish blockages to restore access to new or historical habitats. In the short term, these activities may include in-channel construction of culverts through existing roadways.

#### *Cattle Exclusion Fencing*

Cattle exclusion would include the construction of fencing as allowed by federal and state regulations and local land management plans to prevent cattle from trampling stream banks and would allow the regeneration of riparian vegetation and improving channel structure. Cattle exclusion may be conducted in conjunction with riparian planting as part of the aforementioned floodplain rehabilitation activities. In the long-term, these activities would decrease fine sediment inputs and associated nutrients (primarily phosphorus) to water bodies in the Klamath Basin and promote increased stream shading and reduced summer water temperatures.

#### *Mechanical Thinning and Prescribed Burning*

Mechanical thinning and prescribed burning of upland forest areas may be used to mimic some of the functions and characteristics historically provided by a natural fire regime. In the long term, thinning and prescribed burning may reduce the potential for catastrophic fires and the associated high rates of erosion and nutrient release (primarily phosphorus) to tributaries and the main-stem Klamath River.

*Purchase of Conservation Easements and/or Land*

Purchase of conservation easements and land from willing sellers may allow for more direct land management for habitat enhancement purposes, where the majority of the land involved would be agricultural land. In the long term, these activities would remove acreage from fertilizer and pesticide/herbicide applications, and would decrease nutrients (primarily nitrogen) and organic contaminants runoff to the Klamath River.

*Road Decommissioning*

Road decommissioning would reduce road densities in areas with a high potential for slope failure and would stabilize hillsides. These activities would decrease the incidence of road failure and would minimize a source of chronic fine sediment and nutrient (primarily phosphorus) input into water bodies in the Klamath Basin.

*Treatment of Fine Sediment Sources*

Treatment of fine sediment sources would include management of stormwater runoff from roads and improved agricultural and forestry management practices. In the long term, these activities would help decrease the input of fine sediment and associated nutrients (primarily phosphorus) into water bodies in the Klamath Basin.

*Gravel Augmentation*

Gravel augmentation involves the direct placement of spawning size gravel into the stream channel. Gravel augmentation can increase spawning habitat in systems by increasing the amount of area with suitable substrate. Gravel augmentation activities may involve transportation of gravel from an off-site source using dump trucks and placement in the stream using backhoes. In the short term, these activities would increase suspended sediments in waters proximal to the gravel deposition site and would increase the potential for inorganic and organic contaminants from hazardous materials associated with construction activities.

Individual resource management actions under the Phase I Fisheries Restoration Plan would require separate project-level evaluations under NEPA and ESA; at the programmatic level considered for this EIS/EIR, there is insufficient information to evaluate project-specific short-term (i.e., during construction activities) effects on water quality from these actions. The timing of and specific locations where these resource management actions could be undertaken is not certain, but it is assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Although negative short-term effects of increased suspended sediments and increased potential for inorganic and organic contaminants from hazardous materials associated with construction equipment could occur, implementation of construction-related BMPs would occur as part of the Phase I Fisheries Plan resource management actions. **Given these BMPs (including the BMP requiring biodegradable oils in construction equipment used in streams or rivers, see Appendix B.1.1 Water Quality, the short-term effects on suspended sediment concentrations and inorganic and organic contaminants would be less-than-significant.**



In the long term, most of the above resource management actions would reduce fine sediment inputs into streams in the Klamath Basin. Treatment of fine sediment sources may also include other management actions, including managing stormwater runoff from roads and other developed areas, improved agricultural and forestry management practices, and other specific actions depending on the sources of fine sediments. The Phase I Fisheries Restoration Plan activities would also improve shading and thus cool summer water temperatures, increase riparian and wetland nutrient interception and transformation, and increase dissolved oxygen levels (through decreased water temperatures and decreased nutrient loading). As noted above the timing of and specific locations where these resource management actions could be undertaken is not certain, but it is assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. **Resource management actions implemented under the KBRA Phase I Fisheries Restoration Plan would accelerate long-term improvements in fine sediment, water temperature, nutrients, and dissolved oxygen in the Klamath Basin and would be beneficial.**

#### Phase II Fisheries Restoration Plan

*Implementation of the Phase II Fisheries Restoration Plan under the KBRA (see KBRA Section 10.2) would include a continuation of the same types of resource management actions as under Phase I along with provisions for adaptive management of these actions and would therefore have the same short-term (i.e., during construction activities) and long-term impacts as Phase I.* Individual resource management actions under the Phase II Fisheries Restoration Plan would require separate project-level evaluations under NEPA and ESA; at the programmatic level considered for this EIS/EIR, there is insufficient information to evaluate project-specific short-term (i.e., during construction activities) effects on water quality from these actions. The timing of and specific locations where these resource management actions could be undertaken is not certain but it is assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Although short-term adverse effects of increased suspended sediments and increased potential for inorganic and organic contaminants from hazardous materials associated with construction equipment could occur, implementation of construction-related BMPs would occur as part of the Phase II Fisheries Plan resource management actions. **Given these BMPs (see Appendix B.1.1 Water Quality), the short-term effects on suspended sediment concentrations and inorganic and organic contaminants would be less-than-significant. Resource management actions implemented under the KBRA Phase II Fisheries Restoration Plan would accelerate long-term improvements in fine sediment, water temperature, nutrients, and dissolved oxygen in the Klamath Basin and would be beneficial.**

#### Fisheries Reintroduction and Management Plan

*Implementation of the trap and haul element of the Fisheries Reintroduction and Management Plan could affect water quality during construction.* In the short-term (i.e., during construction activities), constructing fish handling facilities downstream from Keno Dam and at Link River Dam would involve the use of construction equipment for site work and building construction. These activities could increase suspended sediments

and increase the potential for inorganic and organic contaminants from hazardous materials associated with construction activities. Although negative short-term effects could occur, implementation of construction-related BMPs would reduce these effects.

**Given these BMPs (see Appendix B.1.1 Water Quality), the short-term effects on water quality would be less-than-significant.**

#### Wood River Wetland Restoration

*Implementation of Wood River Wetland Restoration could result in warmer long-term spring water temperatures and reduced fine sediment and nutrient inputs to Upper Klamath Lake.* Under the KBRA, the Wood River Wetland Restoration Project (see KBRA Section 18.2.3) would be a new project designed to provide additional water storage for a total of 16,000 acre-feet (AF) of storage in or adjacent to Agency Lake (see Section 2.4.3.8). Wood River Wetland is approximately 3,200 acres in size and is adjacent to Agency Lake and to the north of Agency Lake Ranch. Over 3,000 acres of wetland and two miles of Wood River channel have or are undergoing restoration actions. Options for water management may include using diked areas for pumped storage or breaching levees to reconnect former wetland areas to Agency Lake. Long-term water quality effects associated with the Wood River Restoration Project include the creation of warmer spring temperatures that would be beneficial for rearing juvenile fish in the wetlands (as compared to the cooler temperatures in the Wood River or Upper Klamath Lake) and improved interception and treatment of fine sediment from the Wood River, prior to entering Agency Lake. This may decrease overall nutrient inputs to Upper Klamath Lake by inundating wetland (peat) soils and creating anaerobic conditions that support nutrient retention, particularly in the case of phosphorus (Snyder and Morace 1997). Specific options still need to be developed and studied as part of a separate project-level NEPA evaluation and ESA consultation. There is insufficient information to evaluate project-specific construction-related effects on water quality from the Wood River Wetland Restoration project. The geographic location and timing of this project reduce the potential for any negative water quality effects generated by this action from contributing to the effects of the hydroelectric facility removal actions analyzed above. Although negative short-term effects could occur, implementation of construction-related BMPs would occur. **Given these BMPs (see Appendix B.1.1 Water Quality), the short-term effects would be less-than-significant. Under the KBRA, the Wood River Wetland Restoration Project would accelerate ongoing long-term improvements in water temperature, fine sediment, and nutrients in Agency Lake and would be beneficial.**

#### Water Diversion Limitations

*Implementation of Water Diversion Limitations could result in long-term decreased summer water temperatures in the Klamath River upstream of the Hydroelectric Reach.* Under the KBRA, the Water Diversions Limitations (see KBRA Section 15.1) would be a new project that provides specific allocations of water for refuges and limitations on specific diversions for Reclamation's Klamath Project (see Section 2.4.3.8). Actions reducing availability of irrigation water would increase stream flow and decrease summer water temperatures in the Klamath River upstream of the Hydroelectric Reach, as needed for fisheries. The water quality improvements generated by these water diversion

limitations would contribute to the long-term improvements anticipated from hydroelectric facility removal. **In the short term, there would be no change from existing conditions on water quality. In the long term, the KBRA Water Diversion Limitations would decrease summer water temperatures in the Klamath River upstream of the Hydroelectric Reach and would be beneficial.**

#### Water Use Retirement Program

*Implementation of the Water Use Retirement Program could result in long-term decreases in summer water temperature and nutrient inputs to Upper Klamath Lake.*

Under the KBRA, the Water Use Retirement Program (WURP) (see KBRA Section 16.2.2) would be a new project that seeks to increase the inflow to Upper Klamath Lake by 30,000 acre-feet on an average annual basis (see Section 2.4.3.8). Actions reducing surface water use, such as the sale and retirement of irrigation surface water rights, split season irrigation, shift to dryland crops, and fallowing of crop land, would increase stream flows through decreased surface water withdrawals and increased groundwater recharge. Increased stream flows would improve water quality by decreasing summer water temperatures and decreased irrigation and fallowing of crop land would decrease fertilizer (nutrient) and pesticide/herbicide (inorganic and organic contaminants) inputs. The water quality improvements generated by the WURP would contribute to the long-term improvements anticipated from hydroelectric facility removal. **In the short-term, there would be no change from existing conditions on water quality. The KBRA Water Use Retirement Program would decrease long-term water temperatures and decrease nutrients in Upper Klamath Lake and would be beneficial.**

#### Interim Flow and Lake Level Program

*Implementation of the Interim Flow and Lake Level Program could result in long-term decreases in summer water temperature and nutrient inputs to Upper Klamath Lake.*

Under the KBRA, the Interim Flow and Lake Level Program (see KBRA Section 20.4) would be an interim program of water purchase and lease to further the goals of the fisheries programs during the interim period prior to full implementation of the On-Project Allocation and WURP. Because it is focused on reducing surface water use, it would have the same effects on water quality as the WURP. The water quality improvements generated by the Interim Flow and Lake Level Program would contribute to the long-term improvements anticipated from hydroelectric facility removal. **In the short-term, there would be no change from existing conditions on water quality. The KBRA Interim Flow and Lake Level Program would decrease long-term water temperatures and decrease nutrients in Upper Klamath Lake and would be beneficial.**

#### Upper Klamath Lake and Keno Nutrient Reduction

*Implementation of the Upper Klamath Lake and Keno Nutrient Reduction Program could result in long-term decreases in nutrient inputs, increases in seasonal dissolved oxygen, and decreases in concentrations of nuisance algal species in these waterbodies.* KBRA (Appendix C-2, line 11) includes a program to study and reduce nutrient concentrations in the Keno Impoundment and Upper Klamath Lake in order to reduce dissolved oxygen and nuisance algal problems in both water bodies. Restoration actions to control

nutrients have not been developed, and there are many possible actions that could require construction of treatment wetlands, construction of facilities, or chemical treatments of bottom sediment, among other possibilities. A nutrient reduction program in the Keno Impoundment and Upper Klamath Lake would be designed to improve water quality (increasing seasonally low dissolved oxygen and reducing seasonal algal blooms) and fish passage through the Keno Impoundment in summer and fall months, however implementation of this nutrient reduction program will require future environmental compliance investigations and a determination on significance cannot be made at this time.

#### **3.2.4.3.3 Alternative 3: Partial Facilities Removal of Four Dams**

The Partial Facilities Removal of Four Dams Alternative would remove enough of the material from each dam to allow the river to retain a free-flowing condition and volitional fish passage under all river stages and flow conditions. Some portion of each dam and much of the appurtenant infrastructure would remain, such as the dam foundations, power houses, buildings, tunnels, and pipes. All tunnel openings would be sealed with concrete, remaining buildings would be fenced, and all hazardous materials would be removed from the site. This alternative would include the transfer of the Keno Facility to the DOI and implementation of the KBRA. The Partial Facilities Removal of Four Dams Alternative would result in the release of sediments trapped behind the dams and would have the same short-term (<2 years following dam removal) effects on suspended sediments, dissolved oxygen, nutrients, and inorganic and organic contaminant concentrations in both the Upper and Lower Klamath Basin as the Proposed Action, as follows:

- **The short-term increases in SSCs in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a significant impact.**
- **The short-term decrease in dissolved oxygen concentrations would be a significant impact on the lower Klamath River from Iron Gate Dam to approximately Clear Creek (≈RM 100). There would be no change from existing conditions on the Klamath Estuary or the marine nearshore environment.**
- **The short-term increase in nutrients in the Hydroelectric Reach, the lower Klamath River, and the Klamath Estuary would be a less-than-significant impact.**
- **The short-term effects on organic and inorganic contaminants in the Hydroelectric Reach, the lower Klamath River, and the Klamath Estuary would be a less-than-significant impact.**

**Dam deconstruction activities under the *Partial Facilities Removal of Four Dams Alternative* would have the same short-term effects on suspended sediments in the Hydroelectric Reach, the lower Klamath River, and the Klamath Estuary as the Proposed Action and would be a less-than-significant impact. There would be no change from existing conditions on the marine nearshore environment.**

**Construction activities associated with implementation of IMs 7 (J.C. Boyle Gravel Placement and/or Habitat Enhancement) and 16 (Water Diversions) would have the same short-term effects on suspended sediments in the Hydroelectric Reach as the Proposed Action and would be a less-than-significant impact. There would be no change from existing conditions on the lower Klamath River, Klamath Estuary, or the marine nearshore environment.**

**Construction activities for the Yreka Pipeline under the *Partial Facilities Removal of Four Dams Alternative* would have the same short-term effects on suspended sediments in the Hydroelectric Reach as the Proposed Action and would be a less-than-significant impact. There would be no change from existing conditions on the lower Klamath River, Klamath Estuary, or the marine nearshore environment.**

**Revegetation activities (i.e., hydroseeding) under the *Partial Facilities Removal of Four Dams Alternative* would have the same short-term effects on erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach and transport into the lower Klamath River and Klamath Estuary as the Proposed Action and would be beneficial. There would be no change from existing conditions on the marine nearshore environment.**

Under the Partial Facilities Removal Alternative, interception and retention of sediments and nutrients behind the dams at the Four Facilities would no longer occur and would have the same long-term (2–50 years following dam removal) effects in both the Upper and Lower Klamath Basin as the Proposed Action. **Long-term increases in suspended sediments and nutrients in the Hydroelectric Reach, the lower Klamath River, the Klamath Estuary, and the marine nearshore environment as the Proposed Action and would be a less-than-significant impact.**

Additionally, elimination of the lacustrine environment of the reservoirs would have the same long-term (2–50 years following dam removal) effects on water temperature, dissolved oxygen, pH, algal toxins and chlorophyll-*a*, and inorganic and organic concentrations in both the Upper and Lower Klamath Basin as the Proposed Action, as follows:

- **The long-term increases in summer/fall water temperatures and daily fluctuations in the J.C. Boyle bypass reach due to the elimination of hydropower peaking operations would be a significant impact. Slight decreases in long-term summer/fall water temperatures and less daily fluctuation in the J.C. Boyle peaking reach would be beneficial. Downstream of Copco 1 and Iron Gate Dams, the long-term increase in spring water temperatures would be potentially significant, while the decrease in late summer/fall water temperatures would be beneficial for the Hydroelectric Reach and the lower Klamath River from Iron Gate Dam to the confluence with the Salmon River. There would be no direct effect on water temperature for Klamath River downstream of the Salmon River, the Klamath Estuary, or the marine nearshore environment.**

- **Long-term increases in summer and fall dissolved oxygen concentrations in the Hydroelectric Reach and immediately downstream of Iron Gate Dam would be beneficial. There would be no change from existing conditions on dissolved oxygen by the confluence with the Trinity River.**
- **Long-term summertime increases in pH would be beneficial for the Hydroelectric Reach and the lower Klamath River from Iron Gate Dam to the confluence with the Scott River. There would be no change from existing conditions on pH for Klamath River just downstream of Seiad Valley, the Klamath Estuary, and the marine nearshore environment.**
- **The long-term decrease in production of algal toxins and chlorophyll-*a* in the Hydroelectric Reach and subsequent transport into the lower Klamath River and the Klamath Estuary would be beneficial.**
- **Long-term effects on inorganic and organic contaminants in the Hydroelectric Reach, the lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.**

#### **3.2.4.3.3.1 Keno Transfer**

*Implementation of the Keno Transfer could cause adverse water quality effects.* The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on water quality compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (see KHSA Section 7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

#### **3.2.4.3.3.2 East and West Side Facilities**

*Decommissioning the East and West Side Facilities could cause adverse water quality effects.* Decommissioning of the East and West Side canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA will redirect water flows currently diverted at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there will be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. **Therefore, implementation of the East and West Side Facility Decommissioning action would result in no change from existing conditions.**

#### **3.2.4.3.3.3 KBRA**

KBRA Actions under the Partial Facilities Removal of Four Dams Alternative would be the same as those under the Proposed Action. **Therefore, under the *Partial Facilities Removal of Four Dams Alternative*, KBRA actions would accelerate long-term improvements in water quality (i.e., suspended sediment, water temperature, nutrients, and dissolved oxygen) anticipated under KHSA implementation (i.e., dam removal) and would be beneficial.**

#### **3.2.4.3.4 Alternative 4: Fish Passage at Four Dams**

The Fish Passage at Four Dams Alternative would provide upstream and downstream fish passage at the Four Facilities, but would not include implementation of the KBRA. The ongoing restoration actions, described in the No Action alternative, would continue. The alternative would incorporate the mandatory prescriptions from the Departments of Interior and Commerce imposed during the FERC relicensing process, including fishway installation for both upstream and downstream migrations at all facilities and barriers to prevent juvenile salmonid entrainment into turbines. In addition to the fishways, there is a series of flow-related measures, including a condition that requires at least 40 percent of the inflow to the J.C. Boyle reservoir to be released downstream. This alternative would limit generation of peaking power at J.C. Boyle Powerhouse to one day per week as water supplies allow, and would include recreation flows one day a week. The flow requirements would reduce the overall power generation.

Short-term (<2 years following dam removal) effects on water quality from construction activities associated with new fish passage facilities would occur, including increased suspended sediments and increased potential for inorganic and organic contaminants from hazardous materials associated with construction equipment. These short-term effects would be a significant impact. However, the impacts would be reduced through implementation of BMPs for construction activities that occur in or adjacent to the reservoirs and the Klamath River. BMPs would minimize in-water work and would minimize or eliminate the potential for sediment or toxic substances entering the water.

***Under the Fish Passage at Four Dams Alternative, short-term (<2 years following construction of passage facilities) increases in SSCs and potential inorganic and organic contaminants in the Hydroelectric Reach, the lower Klamath River, the Klamath Estuary and the marine nearshore environment due to construction activities would be a less-than-significant impact.***

Under the Fish Passage at Four Dams Alternative, the reduction in frequency of J.C. Boyle peaking operations (from daily to weekly) and overall higher flow releases would result in warmer and more variable water temperatures in the bypass reach during summer and early fall, and cooler temperatures in late fall and winter. These effects would be similar to those under the Proposed Action and would move this short reach away from support of core coldwater habitat during summer and early fall months; however, water temperatures would approach the natural thermal regime of the river. As with the Proposed Action, areas adjacent to the coldwater springs in the bypass reach would continue to serve as thermal refugia for aquatic species because the springs themselves would not be affected by the Fish Passage at Four Dam Alternative. Similar to the Proposed Action, water temperatures in the peaking reach would be slightly cooler and less variable, also due to higher overall flows and the lower frequency of peaking operations at the J.C. Boyle Powerhouse. Further downstream, at the Oregon-California state line, water temperatures would likely be similar to those under the No Action/No Project Alternative since large temperature effects of the peaking operations do not extend this far downstream.

**Under the *Fish Passage at Four Dams Alternative*, long-term (2–50 years following construction of fish passage facilities) increases in summer/fall water temperatures and daily fluctuations in the J.C. Boyle bypass reach, due to the reduction in frequency of hydropower peaking operations and higher overall flows, would be a significant impact. Slight decreases in long-term summer/fall water temperatures and less daily fluctuation in the J.C. Boyle peaking reach would be beneficial. Long-term water temperature effects in the remainder of the Hydroelectric Reach would be similar to those under the No Action/No Project Alternative (i.e., no change from existing conditions).**

The altered (more stable) flow regime in the J.C. Boyle peaking reach may also affect dissolved oxygen, pH, and nutrients due to increased periphyton growth at this location. However, changes in these parameters are not certain; the role of photosynthesis and community respiration from periphyton growth in the peaking reach is unknown because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are uncertain (see Section 3.2.1.1). Other than this potential and unknown effect related to the flow regime downstream of J.C. Boyle Dam, the presence of fish passage facilities at each of the Four Facilities would not affect other long-term water quality parameters in the Hydroelectric Reach. **Under the *Fish Passage at Four Dams Alternative*, long-term (2–50 years following construction of passage facilities) effects on water quality in the Upper or Lower Klamath Basin would be the same as effects under the No Action/No Project Alternative (i.e., no change from existing conditions).**

#### **3.2.4.3.4.1 Trap and Haul – Programmatic Measure**

*Implementation of the trap and haul measure could affect water quality during construction.* In the short-term (i.e., during construction activities), constructing fish handling facilities downstream from Keno Dam and at Link River Dam would involve the use of construction equipment for site work and building construction. These activities could increase suspended sediments and increase the potential for inorganic and organic contaminants from hazardous materials associated with construction activities. Although negative short-term effects could occur, implementation of construction-related BMPs would reduce these effects. **Given these BMPs (see Appendix B.1.1 Water Quality), the short-term effects on water quality would be less-than-significant.**

#### **3.2.4.3.5 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate**

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative proposes to remove the two largest dams in the Hydroelectric Reach and install fishways for volitional fish passage on the remaining installations. Most of the mandatory prescriptions associated with fish passage would still apply to the remaining dams, including flow requirements and standards for fish passage facilities. Alternative 5 would include no peaking power generation or release of flow for recreation at J.C. Boyle Powerhouse because Copco 1 and Iron Gate Dams would not be present to reregulate flows downstream. For the purposes of this analysis, alternatives that would not result in full implementation of the KHSA do not include the KBRA as a connected action to the



alternative. In the Hydroelectric Reach of the Upper Klamath Basin, this alternative would result in the release of sediments trapped behind Copco 1 and Iron Gate Dams. This release would have short-term (<2 years following dam removal/construction of fish passage facilities) effects on sediment and turbidity, dissolved oxygen, nutrients, and inorganic and organic contaminant concentrations in the Klamath River.

Interception and retention of sediments would still occur behind J.C. Boyle and Copco 2 Dams; this would have long-term (2–50 years following dam removal/construction of fish passage facilities) effects on sediment and turbidity. Additionally, elimination of the lacustrine environment of Copco 1 and Iron Gate Reservoirs under this alternative would have long-term effects on water temperature, dissolved oxygen, nutrients, pH, algal toxins and chlorophyll-*a* in the downstream river. The following sections provide detail regarding the anticipated effects of this alternative on water quality.

#### **3.2.4.3.5.1 Water Temperature**

##### **Upper Klamath Basin**

Since Alternative 5 would include no peaking power generation or release of flow for recreation at J.C. Boyle, water temperature effects in the J.C. Boyle bypass and peaking reaches would be the same as under the Proposed Action i.e., warmer and more variable water temperatures in the bypass reach during summer and early fall, and cooler temperatures in late fall and winter; and, slightly cooler and less variable water temperatures in the peaking reach during summer and early fall. Further downstream, at the Oregon-California state line, water temperatures would be similar to those under the No Action/No Project Alternative since large temperature effects of the peaking operations do not extend this far downstream.

Within the remainder of the Hydroelectric Reach, effects on water temperature under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects for the Hydroelectric Reach under the Proposed Action. The effects of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under this alternative would be similar to effects for the lower Klamath River immediately downstream of Iron Gate Dam under the Proposed Action.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, long-term (2–50 years following dam removal/construction of fish passage facilities) increases in summer/fall water temperatures and daily fluctuations in the J.C. Boyle bypass reach due to the elimination of hydropower peaking operations would be a significant impact. Slight decreases in long-term summer/fall water temperatures and less daily fluctuation in the J.C. Boyle peaking reach would be beneficial. From the J.C. Boyle peaking reach to Copco 1 Reservoir, long-term water temperature effects would be similar to those under the No Action/No Project Alternative (i.e., no change from existing conditions). From Copco 1 Reservoir to Iron Gate Reservoir, long-term increases in spring water temperatures would be potentially significant and decreases in late summer/fall***

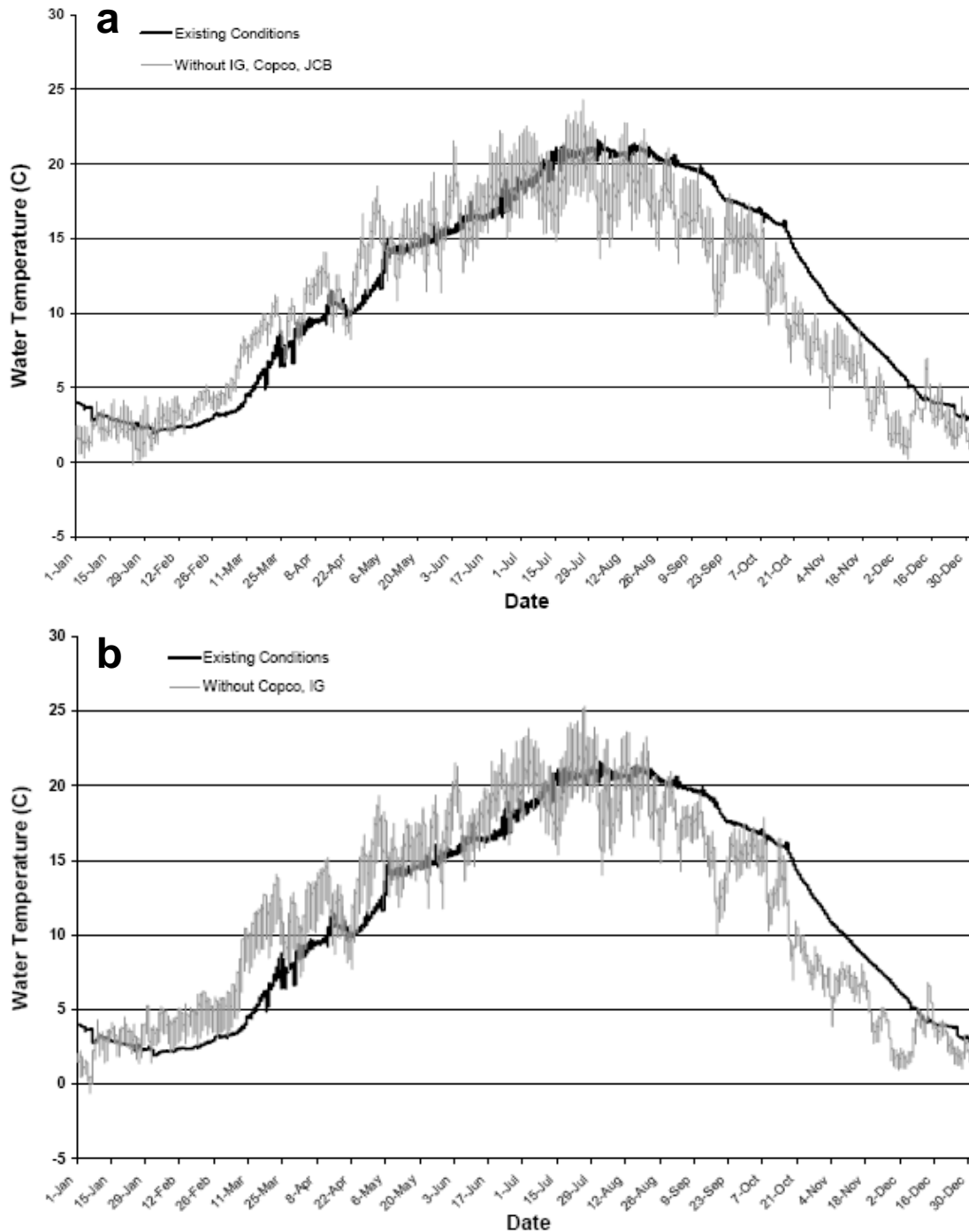
**water temperatures in the Hydroelectric Reach would be similar to the Proposed Action and would be beneficial.**

#### Lower Klamath Basin

While model results analyzed for the Proposed Action do not explicitly isolate the effects of the four individual reservoirs on water temperatures, the KRWQM includes a scenario in which only Iron Gate, Copco 1, and Copco 2 Dams are removed but J.C. Boyle remains in place (“WIGC” PacifiCorp 2004b, Dunsmoor and Huntington 2006, see also Appendix D). This scenario is analogous to the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative because Copco 2 Reservoir has no active storage and thus has a negligible effect on hydraulic residence time and water temperature. KRWQM WIGC results indicate that compared with removal of all four reservoirs (“WIGCJCB”), the long-term effects of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to effects on water temperature for the Lower Klamath Basin under the Proposed Action (see Figure 3.2-26).

This is not surprising because Copco 1 and Iron Gate Reservoirs are the two deepest and largest reservoirs, which stratify during summer months and affect downstream water temperature through the discharge of warm surface waters (see Section 3.2.3.1). Comparison of KRWQM model output for WIGC and WIGCJCB also indicates that springtime daily variability in water temperature may be somewhat greater under this alternative than under the Proposed Action, which may be due to assumptions regarding peaking operations at J.C. Boyle Powerhouse. However, overall, the effects of removing Iron Gate and Copco 1 Dams on water temperature in the Lower Klamath Basin would be similar to effects under the Proposed Action.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the long-term (2-50 years following dam removal/construction of fish passage facilities) increases in spring water temperatures would be potentially significant and decreases in late summer/fall water temperatures would be beneficial for the lower Klamath River from Iron Gate Dam to the confluence with the Salmon River. There would be no change from existing conditions on water temperature for lower Klamath River downstream of the Salmon River, the Klamath Estuary, and the marine nearshore environment.***



**Figure 3.2-26. Simulated Hourly Water Temperature Downstream of Iron Gate Dam (RM 190.1) Based on Year 2004 for Current Conditions Compared to Hypothetical Conditions: (a) without Iron Gate (IG), Copco 1 and 2, and J.C. Boyle (JCB) Dams and (b) without Iron Gate (IG) and Copco 1 and 2 Dams.**  
Source: PacifiCorp 2004a.

### **3.2.4.3.5.2 Suspended Sediments**

#### **Upper Klamath Basin**

Upstream of Copco 1 Dam, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) SSCs under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as SSCs under the No Action/No Project Alternative. However, because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained with the reservoirs at the Four Facilities (CDM 2011), the short-term effects of sediment release on SSCs downstream of Copco 1 Dam under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to effects for the Hydroelectric Reach under the Proposed Action. Compared to the Proposed Action, there would be approximately 15 percent less sediment mobilized from the reservoirs at the Four Facilities (sediments in J.C. Boyle would remain in place) and short-term SSCs within the Hydroelectric Reach may exhibit somewhat lower peaks. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, short-term (<2 years following dam removal/construction of fish passage facilities) increases in SSCs in the Hydroelectric Reach due to mobilization of sediment deposits from Copco 1 Reservoir and Iron Gate Reservoir would be a significant impact.***

Stormwater runoff from deconstruction activities under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 2 and Iron Gate Alternative may cause increases in suspended material in the Hydroelectric Reach during the deconstruction period. Dam deconstruction effects on suspended sediments would be limited to Copco 1 and Iron Gate Reservoirs and downstream river reaches, while fish passage construction effects would be limited to J.C. Boyle and Copco 2 Reservoirs and downstream river reaches. However, both dam deconstruction and fish passage construction activities would be complex and overlapping in terms of resulting river concentrations of suspended sediments and would require implementation of BMPs at each reservoir site. Therefore, dam deconstruction and fish passage construction activities in the Hydroelectric Reach under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be essentially the same as those for the Hydroelectric Reach under the Proposed Action.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, short-term (<2 years following dam removal/construction of fish passage facilities) deconstruction-related increases in SSCs in the Hydroelectric Reach would be a less-than-significant impact.***

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, construction activities for the Yreka Pipeline would have the same short-term effects on suspended sediments in the Hydroelectric Reach as the Proposed Action and would be a less-than-significant impact.***

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, revegetation activities (i.e., hydroseeding) would have the same short-term (< 2 years following dam removal) effects on erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach as the Proposed Action and would be beneficial.**

Due to the lack of continued interception and retention of mineral (inorganic) and algal-derived (organic) suspended materials behind Copco 1 and Iron Gate Dams under the Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative, long-term (2-50 years following dam removal/construction of fish passage facilities) effects on SSCs for the Hydroelectric Reach would be similar to those for the Hydroelectric Reach under the Proposed Action. **Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, long-term (2–50 years following dam removal/construction of fish passage facilities) increases in mineral (inorganic) and algal-derived (organic) suspended material in the Hydroelectric Reach would be a less-than-significant impact.**

#### Lower Klamath Basin

Because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained with the reservoirs at the Four Facilities (CDM 2011), the short-term (<2 years following dam removal/construction of fish passage facilities) effects of sediment release on concentrations of suspended sediments in the Lower Klamath Basin under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to those for the Lower Klamath Basin under the Proposed Action. Because there would be approximately 15 percent less sediment mobilized (sediments in J.C. Boyle would remain in place), short-term (<2 years following dam removal/construction of fish passage facilities) SSCs in the Lower Klamath Basin may exhibit somewhat lower peaks. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect.

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, short-term (<2 years following dam removal/construction of fish passage facilities) increases in SSCs in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.**

Stormwater runoff from deconstruction activities under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate alternative may cause increases in suspended material in the Klamath River downstream of Iron Gate Dam during the deconstruction period. Dam deconstruction effects on suspended sediments would be limited to Copco 1 and Iron Gate Reservoirs and downstream river reaches, while fish passage construction effects would be limited to J.C. Boyle and Copco 2 Reservoirs and downstream river reaches. However, both dam deconstruction and fish passage construction activities would be complex and overlapping in terms of river SSCs and would require implementation of BMPs at each reservoir site. Therefore, dam deconstruction and fish passage construction activities would have the same effects on

SSCs in the Lower Klamath Basin as the Proposed Action and the Fish Passage at Four Dams Alternative.

***Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, deconstruction-related increases in SSCs in the lower Klamath River and the Klamath Estuary would be a less-than-significant impact. There would be no change from existing conditions on the marine nearshore environment.***

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, revegetation activities (i.e., hydroseeding) would have the same short-term (< 2 years following dam removal) effects on erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach and transport into the lower Klamath River and Klamath Estuary as the Proposed Action and would be beneficial. There would be no change from existing conditions on the marine nearshore environment.***

Under this alternative, long-term (2–50 years following dam removal/construction of fish passage facilities) effects on mineral (inorganic) and algal-derived (organic) suspended materials in the Lower Klamath Basin due to the lack of continued interception and retention of sediment behind Copco 1 and Iron Gate Dams would be similar to those for the Lower Klamath Basin under the Proposed Action.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the long-term (2–50 years following dam removal/construction of fish passage facilities) increases on mineral (inorganic) and algal-derived (organic) suspended materials in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.***

### **3.2.4.3.5.3 Nutrients**

#### **Upper Klamath Basin**

Upstream of Copco 1 Reservoir, effects on nutrients under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects under the No Action/No Project Alternative because J.C. Boyle Dam would remain in place. However, Copco 1 and Iron Gate Reservoirs are the largest and deepest reservoirs in the Hydroelectric Reach with the longest residence times (FERC 2007), and the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) the effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on nutrients would be the same as effects for the lower Klamath River immediately downstream of Iron Gate Dam under the Proposed Action.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish***

**passage facilities) increases in nutrients in the Hydroelectric Reach would be a less-than-significant impact.**

#### Lower Klamath Basin

Copco 1 and Iron Gate Reservoirs are the largest and deepest reservoirs in the Hydroelectric Reach with the longest residence times, so the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on nutrients would be the same as effects for the lower Klamath River under the Proposed Action.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) increases in nutrients in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.***

#### **3.2.4.3.5.4 Dissolved Oxygen**

##### Upper Klamath Basin

Upstream of Copco 1 Dam, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) dissolved oxygen under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as dissolved oxygen under the No Action/No Project Alternative. However, because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained within the reservoirs at the Four Facilities (CDM 2011), the short-term effects of sediment release on dissolved oxygen concentrations downstream of Copco 1 Dam under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to effects for the Hydroelectric Reach under the Proposed Action. Compared to the Proposed Action, there would be approximately 15 percent less sediment mobilized (sediments in J.C. Boyle would remain in place) and short-term SSCs in the Lower Klamath Basin may exhibit somewhat lower peaks. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect on dissolved oxygen. The short-term effects of sediment release on oxygen demand and dissolved oxygen concentrations in the Hydroelectric Reach under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be essentially the same as those for the Lower Klamath Basin under the Proposed Action.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, short-term (<2 years following dam removal/construction of fish passage facilities) decreases in dissolved oxygen in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir would be a significant impact. The long-term (2-50 years following dam removal) increase in summer and fall dissolved oxygen concentrations in the Hydroelectric Reach would be beneficial.***

#### Lower Klamath Basin

Because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained within the reservoirs at the Four Facilities (CDM 2011), the short-term (<2 years following dam removal/construction of fish passage facilities) effects of sediment release on concentrations of dissolved oxygen in the Lower Klamath Basin under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to those for the Lower Klamath Basin under the Proposed Action. Because there would be approximately 15 percent less sediment mobilized (sediments in J.C. Boyle would remain in place), short-term SSCs in the Lower Klamath Basin may exhibit somewhat lower peaks and dissolved oxygen demand may also decrease. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect on dissolved oxygen.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the short-term (<2 years following dam removal/construction of fish passage facilities) decrease in dissolved oxygen concentrations would be a significant impact on the lower basin from Iron Gate Dam to approximately Clear Creek (≈RM 100), but would not affect dissolved oxygen in the Klamath Estuary or the marine nearshore environment. The long-term (2–50 years following dam removal) increases in summer and fall dissolved oxygen concentrations immediately downstream of Iron Gate Dam would be beneficial.***

#### **3.2.4.3.5.5 pH**

##### Upper Klamath Basin

Upstream of Copco 1 Reservoir, effects on pH under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects under the No Action/No Project Alternative because J.C. Boyle Dam would remain in place. The effects of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under this alternative would be similar to effects on pH for the lower Klamath River immediately downstream of Iron Gate Dam under the Proposed Action.

***Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the long-term (2–50 years following dam removal/construction of fish passage facilities) decrease in high summertime daily pH fluctuations in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir would be beneficial.***

##### Lower Klamath Basin

Because J.C. Boyle Reservoir does not currently appear to substantially alter pH in the river downstream of the dam (see Figure 3.2-22. ) having this dam in place would not affect pH downstream of the Hydroelectric Reach in the Lower Klamath Basin. However, apparent seasonal and daily pH fluctuations in Copco 1 and Iron Gate Reservoirs would be altered once these reservoir areas were converted to a free-flowing river. Therefore, effects on pH under this alternative would be similar to effects on pH



for the lower Klamath River immediately downstream of Iron Gate Dam under the Proposed Action.

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, long-term (2–50 years following dam removal/construction of fish passage facilities) summertime increases in pH would be less than significant for the lower Klamath River from Iron Gate Dam to the confluence with the Scott River. There would be no change from existing conditions on pH for the Klamath River just downstream of Seiad Valley, the Klamath Estuary, and the marine nearshore environment.**

#### **3.2.4.3.5.6 *Chlorophyll-a and Algal Toxins***

##### **Upper Klamath Basin**

Upstream of Copco 1 Reservoir, effects on algal toxins and chlorophyll-*a* under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects under the No Action/No Project Alternative because J.C. Boyle Dam would remain in place. Copco 1 and Iron Gate Reservoirs are the largest reservoirs in the Hydroelectric Reach with the longest hydraulic residence times (FERC 2007) and potential for *in situ* algal growth, so the effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on algal toxins and chlorophyll-*a* would be the same as effects for the Upper Klamath Basin under the Proposed Action.

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2–50 years following dam removal/construction of fish passage facilities) decrease in production of algal toxins and chlorophyll-*a* in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir would be beneficial.**

##### **Lower Klamath Basin**

Copco 1 and Iron Gate Reservoirs are the largest reservoirs in the Hydroelectric Reach with the longest residence times (FERC 2007) and hence potential for *in situ* algal growth, so the effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on algal toxins and chlorophyll-*a* would be the same as effects for the Lower Klamath Basin under the Proposed Action.

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2–50 years following dam removal/construction of fish passage facilities) decrease in production of algal toxins and chlorophyll-*a* in upstream reservoirs and subsequent transport into the lower Klamath River and the Klamath Estuary would be beneficial.**

### **3.2.4.3.5.7 Inorganic and Organic Contaminants**

#### **Upper Klamath Basin**

Under this alternative, continued retention of sediments behind J.C. Boyle Dam and release of sediments trapped behind Copco 1 and Iron Gate Dams would occur. In J.C. Boyle Reservoir, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) effects of sediment retention on concentrations of inorganic and organic contaminants, and the potential for bioaccumulation and/or toxicity to freshwater aquatic biota and humans, would be the same as those for the Hydroelectric Reach under the No Action/No Project Alternative. However, for the two largest reservoirs in the Hydroelectric Reach, Copco 1 and Iron Gate Reservoirs, short-term and long-term effects of sediment release on concentrations of inorganic and organic contaminants under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as those for the Hydroelectric Reach under the Proposed Action.

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) increases in potential inorganic and organic contaminants in the Hydroelectric Reach due to sediment release would be a less-than-significant impact.**

*Dam deconstruction and fish passage construction activities could cause increases in inorganic and organic contaminants from hazardous materials associated with construction equipment that could exceed applicable Oregon DEQ and North Coast Basin Plan water quality objectives and adversely affect beneficial uses in the Hydroelectric Reach.* These effects would be a significant impact. However, the impacts would be reduced through implementation of BMPs for deconstruction and construction activities that would occur in or adjacent to the Klamath. BMPs would minimize or eliminate the potential for toxic substances to enter the water.

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the effects on inorganic and organic contaminants in the Hydroelectric Reach due to construction/deconstruction activities would be a less-than-significant impact.**

#### **Lower Klamath Basin**

Under this alternative, release of the sediments trapped behind Copco 1 and Iron Gate Dams) would occur. Because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained within the reservoirs at the Four Facilities (CDM 2011), the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) effects of sediment release on concentrations of inorganic and organic contaminants, and the potential for bioaccumulation and/or toxicity to freshwater aquatic biota, marine aquatic biota, and humans in the Lower Klamath Basin, would be similar to those for the Lower Klamath Basin under the Proposed Action.

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) increases in potential inorganic and organic contaminants due to sediment release would be a less-than-significant impact.**

*Dam deconstruction and fish passage construction activities could cause increases in inorganic and organic contaminants from hazardous materials associated with construction equipment that could exceed applicable North Coast Basin Plan water quality objectives and adversely affect beneficial uses in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment. These effects would be a significant impact. However, the impacts would be reduced through implementation of BMPs for deconstruction and construction activities that would occur in or adjacent to the Klamath River. BMPs would minimize or eliminate the potential for toxic substances to enter the water.*

**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the increases in potential inorganic and organic contaminants due to construction/deconstruction activities would be a less-than-significant impact.**

#### **3.2.4.3.5.8 Trap and Haul – Programmatic Measure**

The impacts from the trap and haul measure under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as those under the Fish Passage at Four Dams Alternative. **Therefore, under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the short-term effects on water quality would be less-than-significant because of implementation of BMPs (see Appendix B.1.1 Water Quality).**

#### **3.2.5 Mitigation Measures**

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects (i.e., high SSCs, low DO) (see also Section 2, Proposed Action and Description of the Alternatives). While the Alternatives Formulation Report identified the option of mechanical sediment removal as mitigation for sediment erosion impacts associated with removal of the Four Facilities, subsequent analysis found this measure to be infeasible (Lynch 2011).

#### **3.2.5.1 Mitigation Measures Associated with Other Resource Areas**

Several other mitigation measures require construction, including mitigation measures H-2 (flood-proof structures), GW-1 (deepen or replace affected wells), WRWS-1 (modify or screen affected water intakes), PHS-4 (repair damaged roads), PHS-5 (construct water storage tanks for fire fighting), REC-1 (develop new recreational facilities and access to river), TR-6 (assess and improve roads to carry construction loads), and TR-7 (assess and improve bridges to carry construction loads). Short-term effects on water quality from construction activities may include increased suspended sediments and inorganic and organic contaminants from hazardous materials associated with construction equipment to enter nearby or adjacent water bodies. Implementation of deconstruction and/or construction-related BMPs would also apply to these construction efforts.

**Implementation of BMPs would reduce effects of these mitigation measures to less-than-significant levels.**

#### **3.2.6 Summary of Short-term and Long-term Impacts on Water Quality**

Table 3.2-14 summarizes the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) impacts of the Proposed Action and alternatives on water quality.

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
<b><i>Water Temperature</i></b>				
<b>Upper Klamath Basin</b>				
Continued impoundment of water in the reservoirs could cause short-term and long-term seasonal water temperatures that are shifted from the natural thermal regime of the river and do not meet applicable ODEQ and California Basin Plan water quality objectives and adversely affect beneficial uses in the Hydroelectric Reach.	1, 4, 5	NCFEC	None	NCFEC
Dam removal and/or elimination of hydropower peaking operations at J.C. Boyle Powerhouse could cause short-term and long-term alterations in daily water temperatures and fluctuations in the J.C. Boyle bypass and peaking reaches.	2, 3, 5	S for J.C. Boyle bypass reach B for J.C. Boyle peaking reach	None	S for J.C. Boyle bypass reach B for J.C. Boyle peaking reach
Dam removal and conversion of the reservoir areas to a free-flowing river could cause short-term and long-term increases in spring time water temperatures and decreases in late summer/fall water temperatures in the Hydroelectric Reach downstream of Copco 1 Reservoir.	2, 3, 5	S for springtime B for late summer/fall	None	S for springtime B for late summer/fall
<b>Lower Klamath Basin</b>				
Draining the reservoirs and release of sediment could cause short-term and long-term increases in sediment deposition in the Klamath River or Estuary that could alter morphological characteristics and indirectly affect seasonal water temperatures.	2, 3, 5	NCFEC	None	NCFEC

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Continued impoundment of water in the reservoirs could cause short-term and long-term seasonal water temperatures that are shifted from the natural thermal regime of the river and do not meet applicable California North Coast Basin Plan water quality objectives and adversely affect beneficial uses in the Klamath River downstream of Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free flowing river could result in short-term and long-term increases in spring water temperatures and decreases in late summer/fall water temperatures in the Lower Klamath River.	2,3,5	S – Iron Gate Dam to Salmon River for springtime and B – in late summer/fall NCFEC – Klamath River downstream of Salmon River, the Klamath Estuary, and marine near shore environment	None	S – Iron Gate Dam to Salmon River for springtime and B – in late summer/fall NCFEC – Klamath River downstream of Salmon River, the Klamath Estuary, and marine near shore environment
<b><i>Suspended Sediments</i></b>				
<b>Upper Klamath Basin</b>				
Continued impoundment of water in the reservoirs could result in short-term and long-term interception and retention of mineral (inorganic) suspended material by the KHP dams.	1, 4	NCFEC	None	NCFEC
Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach.	1 ,2 ,3	LTS	None	LTS
Implementation of IM 8, J.C. Boyle Bypass Barrier Removal, could result in short-term increases in mineral suspended material in the Hydroelectric Reach due to deconstruction activities.	1	LTS	None	LTS

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Implementation of IM 16, Water Diversions, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach due to diversion screening deconstruction and construction activities.	2, 3	LTS	None	LTS
Continued impoundment of water in the reservoirs could cause short-term and long-term seasonal (April through October) increases in algal-derived (organic) suspended material in the Hydroelectric Reach due to in-reservoir algal blooms.	1, 4	NCFEC	None	NCFEC
Draining the reservoirs and release of sediment could cause short-term increases in suspended material in the Hydroelectric Reach downstream of J.C. Boyle Dam.	2, 3, 5	S	None	S
Construction/deconstruction activities could cause short-term increases in suspended material in the Hydroelectric Reach due to stormwater runoff from construction/deconstruction areas.	2, 3, 4, 5	LTS	None	LTS
Removal of Iron Gate Dam would require relocation of the Yreka Water Supply Pipeline which could cause short-term increases in suspended material in the Hydroelectric Reach during the construction period.	2, 3, 5	LTS	None	LTS
Construction/deconstruction activities would include the demolition of various recreation facilities which could cause short-term increases in suspended material in the Hydroelectric Reach from stormwater runoff from the demolition areas.	2, 3, 5	LTS	None	LTS
Revegetation associated with management of the reservoir footprint area after dam removal could decrease the short-term erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach.	2, 3, 5	B	None	B

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Dam removal could eliminate the interception and retention of mineral (inorganic) suspended material behind the dams and result in long-term increases in suspended material in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Dam removal could eliminate the interception and retention of algal-derived (organic) suspended material behind the dams and result in long-term increases in suspended material in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
<b>Lower Klamath Basin</b>				
Draining the reservoirs and release of sediment could cause short-term increases in suspended material in the lower Klamath River and the Klamath Estuary.	2, 3, 5	S	None	S
Draining the reservoirs and release of sediment could cause short-term increases in sediment loads from the Klamath River to the Pacific Ocean and corresponding increases in concentrations of suspended material and rates of deposition in the marine nearshore environment.	2, 3, 5	LTS	None	LTS



**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Continued impoundment of water in the reservoirs could cause short-term and long-term interception and retention of mineral (inorganic) sediments by the dams and correspondingly low levels of suspended material immediately downstream of Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Continued impoundment of water in the reservoirs could result in short-term and long-term seasonal (April through October) increases in algal-derived (organic) suspended material in the KHP reservoirs and subsequent transport into the Klamath River downstream of Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Construction/deconstruction activities could cause short-term increases in suspended material in the lower Klamath River, Klamath Estuary, and marine nearshore environment due to stormwater runoff from construction/deconstruction areas.	2, 3, 5	LTS	None	LTS
Revegetation associated with management of the reservoir footprint area after dam removal could decrease the short-term erosion of fine sediments from exposed reservoir terraces into the lower Klamath River and Klamath Estuary.	2, 3, 5	B	None	B
Dam removal could eliminate the interception and retention of mineral (inorganic) suspended material behind the dams and result in long-term increases in suspended material in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS
Dam removal could eliminate the interception and retention of algal-derived (organic) suspended material behind the dams and result in long-term increases in suspended material in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
<b>Nutrients</b>				
<b>Upper Klamath Basin</b>				
Continued impoundment of water in the reservoirs could result in long-term interception and retention of TP and TN in the Hydroelectric Reach on an annual basis but release (export) of TP and TN from reservoir sediments on a seasonal basis.	1, 4	NCFEC	None	NCFEC
Draining the reservoirs and release of sediment could cause short-term increases in sediment-associated nutrients in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
<b>Lower Klamath Basin</b>				
Continued impoundment of water in the reservoirs could cause long-term interception and retention of TP and TN on an annual basis but release (export) of TP and TN on a seasonal basis	1, 4	NCFEC	None	NCFEC
Draining the reservoirs and release of sediment to the lower Klamath River could cause short-term increases in sediment-associated nutrients in the river and the Klamath Estuary.	2, 3, 5	LTS	None	LTS
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
<b><i>Dissolved Oxygen</i></b>				
<b>Upper Klamath Basin</b>				
Continued impoundment of water in the reservoirs could cause long-term <sup>7</sup> seasonal and daily variability in dissolved oxygen concentrations in the Hydroelectric Reach, such that levels do not meet Oregon DEQ and California North Coast Basin Plan water quality objectives and adversely affect beneficial uses.	1, 4	NCFEC	None	NCFEC
Draining the reservoirs and release of sediment could cause short-term <sup>8</sup> increases in oxygen demand (Immediate Oxygen Demand [IOD] and Biological Oxygen Demand [BOD]) and reductions in dissolved oxygen in the Hydroelectric Reach downstream of J.C. Boyle Reservoir.	2, 3, 5	S	None	S
Dam removal and conversion of reservoir areas to free-flowing river conditions could cause long-term increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the Hydroelectric Reach.	2, 3	B	None	B
<b>Lower Klamath Basin</b>				
Continued impoundment of water in the reservoirs could cause long-term seasonal and daily variability in dissolved oxygen concentrations in the Klamath River downstream of Iron Gate Dam, such that levels do not meet California North Coast Basin Plan and Hoopa Valley Tribe water quality objectives and adversely affect beneficial uses.	1, 4	NCFEC	None	NCFEC

<sup>7</sup> Long-term is defined as 2-50 years

<sup>8</sup> Short-term is defined as <2 years

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Dam removal and sediment release could cause short-term increases in oxygen demand (Immediate Oxygen Demand [IOD] and Biological Oxygen Demand [BOD]) and reductions in dissolved oxygen in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	S (lower Klamath River from Iron Gate Dam to Clear Creek) NCFEC (Klamath Estuary or Marine Nearshore Environment)	None	S (lower Klamath River from Iron Gate Dam to Clear Creek) NCFEC (Klamath Estuary or Marine Nearshore Environment)
Dam removal and conversion of reservoir areas to a free-flowing river could cause long-term increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the lower Klamath River, particularly for the reach immediately downstream of Iron Gate Dam.	2, 3, 5	B	None	B
<b>pH</b>				
<b>Upper Klamath Basin</b>				
Continued impoundment of water in the reservoirs could cause long-term elevated seasonal pH and daily variability in pH in the Hydroelectric Reach.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free-flowing river could cause short-term and long-term decreases in summertime pH in the Hydroelectric Reach.	2, 3, 5	B	None	B
<b>Lower Klamath Basin</b>				
Continued impoundment of water in the reservoirs could cause long-term elevated seasonal pH and daily variability in pH in the lower Klamath River downstream of Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free-flowing river could cause short-term and long-term decreases in summertime pH in the lower Klamath River, Klamath Estuary, and the marine nearshore environment.	2, 3, 5	B	None	B

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term summertime increases in pH in the lower Klamath River downstream of Iron Gate Dam.	2, 3, 5	LTS (from Iron Gate Dam to confluence with the Scott River) NCFEC (Klamath River just downstream of Seiad Valley, the Klamath Estuary, and the Marine Nearshore Environment	None	LTS (from Iron Gate Dam to confluence with the Scott River) NCFEC (Klamath River just downstream of Seiad Valley, the Klamath Estuary, and the Marine Nearshore Environment
<b><i>Chlorophyll-a and Algal Toxins</i></b>				
<b>Upper Klamath Basin</b>				
Continued impoundment of water in the reservoirs could support long-term growth conditions for toxin-producing nuisance algal species such as <i>M. aeruginosa</i> , resulting in high seasonal concentrations of chlorophyll-a and algal toxins in the Hydroelectric Reach.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free-flowing river would cause short-term and long-term decreases in levels of chlorophyll-a and algal toxins in the Hydroelectric Reach.	2, 3, 5	B	None	B

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
<b>Lower Klamath Basin</b>				
Continued impoundment of water in the reservoirs could support long-term growth conditions for toxin-producing nuisance algal species such as <i>M. aeruginosa</i> , resulting in high seasonal concentrations of chlorophyll-a and algal toxins transported into the Klamath River from downstream of Iron Gate Dam to the Klamath Estuary, and potentially to the marine nearshore environment.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free-flowing river would cause short-term and long-term decreases in levels of chlorophyll-a and algal toxins in the lower Klamath River and the Klamath Estuary.	2, 3, 5	B	None	B
<b>Inorganic and Organic Contaminants</b>				
<b>Upper Klamath Basin</b>				
Continued impoundment of water in the reservoirs and associated interception and retention of sediments behind the dams could cause long-term low-level exposure to inorganic and organic contaminants for freshwater aquatic species in the Hydroelectric Reach.	1, 4, 5	NCFEC	None	NCFEC
Continued impoundment of water in the reservoirs and associated interception and retention of sediments behind the dams could cause long-term low-level exposure to inorganic and organic contaminants in the Hydroelectric Reach through human consumption of resident fish tissue.	1, 4, 5	NCFEC	None	NCFEC
Draining the reservoirs and sediment release could cause short-term increases in concentrations of inorganic and organic contaminants and result in low-level exposure for freshwater aquatic species in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Draining the reservoirs and sediment release could cause short-term human exposure to contaminants from contact with deposited sediments on exposed reservoir terraces and river banks within the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Construction/deconstruction activities could cause short-term increases in inorganic and organic contaminants from hazardous materials associated with construction and revegetation equipment in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Reservoir area restoration activities could include herbicide application which could cause short-term levels of organic contaminants in runoff that are toxic to aquatic biota in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
<b>Lower Klamath Basin</b>				
Dam removal and sediment release could cause short-term and long-term increases in concentrations of inorganic and organic contaminants and result in low-level exposure for freshwater aquatic species in the lower Klamath River and the Klamath Estuary.	2, 3, 5	LTS	None	LTS
Draining the reservoirs and sediment release could cause short-term human exposure to contaminants from contact with deposited sediments on exposed downstream river terraces and downstream river banks following reservoir drawdown.	2, 3, 5	LTS	None	LTS
Construction/deconstruction activities could cause short-term increases in suspended sediments and the potential for inorganic and organic contaminants from hazardous materials associated with construction equipment to be transported into the lower Klamath River, Klamath Estuary, and the marine nearshore environment.	2, 3, 4, 5	LTS	None	LTS
<b>Trip and Haul Operations</b>				

**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Implementation of the trap and haul element of the Fisheries Reintroduction and Management Plan would affect water quality during construction.	4,5	LTS	None	LTS
<b><i>Keno Transfer</i></b>				
Implementation of the Keno Transfer could cause adverse water quality effects.	2, 3	NCFEC	None	NCFEC
<b><i>East and West Side Facilities</i></b>				
Decommissioning the East and West Side Facilities could cause adverse water quality effects.	2, 3	NCFEC	None	NCFEC
<b><i>KBRA</i></b>				
Implementation of the Phase I Fisheries Restoration Plan could result in short-term construction-related increases in suspended materials and long-term reductions in fine sediment inputs, reduced summer water temperatures, improved nutrient interception, and increased dissolved oxygen levels. .	2, 3	LTS (short-term) B (long-term)	None	LTS (short-term) B (long-term)
Implementation of the Phase II Fisheries Restoration Plan under the KBRA (KBRA Section 10.2) would include a continuation of the same types of resource management actions as under Phase I along with provisions for adaptive management of these actions and would therefore have the same short-term (i.e., during construction activities) and long-term impacts as Phase I.	2, 3	LTS (short-term) B (long-term)	None	LTS (short-term) B (long-term)
Implementation of the trap and haul element of the Fisheries Reintroduction and Management Plan could affect water quality during construction.	2,3	LTS	None	LTS
Implementation of Wood River Wetland Restoration could result in short-term construction-related increases in suspended materials and long-term warmer spring water temperatures and reduced fine sediment and nutrient inputs to Upper Klamath Lake.	2, 3	LTS (short-term) B (long-term)	None	LTS (short-term) B (long-term)



**Table 3.2-14. Summary of Short-Term (<2 years) and Long-Term (2–50 years) Water Quality Impacts**

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Implementation of Water Diversion Limitations could result in decreased summer water temperatures in the Klamath River upstream of the Hydroelectric Reach.	2, 3	NCFEC (short-term) B (long-term)	None	NCFEC (short-term) B (long-term)
Implementation of the Water Use Retirement Program could result in decreases in summer water temperature and nutrient inputs to Upper Klamath Lake.	2, 3	NCFEC (short-term) B (long-term)	None	NCFEC (short-term) B (long-term)
Implementation of the Interim Flow and Lake Level Program could result in decreases in summer water temperature and nutrient inputs to Upper Klamath Lake.	2, 3	NCFEC (short-term) B (long-term)	None	NCFEC (short-term) B (long-term)
Implementation of the Upper Klamath Lake and Keno Nutrient Reduction Program could result in long-term decreases in nutrient inputs, increases in seasonal dissolved oxygen, and decreases in concentrations of nuisance algal species in these waterbodies.	2, 3	Not determined at this time	None	Not determined at this time

Key:

NCFEC = No change from existing conditions; B = Beneficial; LTS = Less than significant; S = Significant

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